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WHY THE JAPANESE ISLANDS?

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THE snow on the summit of Fugi San slowly disappears as the summer advances and the peasant thanks the goddess for her bounty of abundant water for the rice fields. But were the snow to melt away in winter time there would be dismay instead of gratitude, for it might mean that Fuji San was awakening from her long slumber and her fires might spread destruction in the populous plains at her feet. Japan has often experienced such rude awakenings of volcanoes long dormant, while others have records of more or less frequent eruptions. When the volcanic fires are rekindled no man knows what terrific powers they may develop. Gradually, during weeks or months, the interior of the mountain heats up. Eventually hot gases and a lava stream pour out or an explosion occurs. The activity continues for a time and then dies away, leaving the steaming cone to relapse into a dormant state. The amount of energy expended is enormous, extraordinary as it seems to us; but it is a normal incident, nothing more, in the earth's long history. What is this persistent source of heat, which throughout all geologic time has been competent to produce such outbursts?

That question was easily answered when we thought, as we used to, that the molten interior of the globe was covered by a thin crust. It might be expected to escape through cracks; the wonder was there were not more eruptions. But now that we know the solid mantle over the core to be at least 1,800 miles thick, the facile explanation no longer works if the mantle is solid and crystalline, not glassy.

Speculation next framed hypotheses upon the assumption that volcanoes originate in the rigid crust, above the elastic, plastic mantle. A number of conditions which might produce a local concentration of heat within a few miles of the surface were considered by different theorists. Might water penetrate the rocky crust to a depth at which, on meeting rocks nearly hot enough to melt or molten, it might cause them to melt by lowering the melting temperature of the minerals. Or, assuming that at a moderate depth there are rocks which are restrained from melting only by great load, could the load be lightened in some way so that they would be able to melt? Or could a buried mass of rock, at high temperature, be crushed in such a manner that the heat of compression and friction would melt it?

While each of these suggestions rests upon a possible physical reaction, no one of them corresponds to the actual conditions of volcanic activity and its distribution. Each one fails when critically faced by the known facts.[1]

[1] Chamberlin and Salisbury, "Geology," Vol. 1, pp. 624 *et sequi.*

One of the most striking phenomena connected with vulcanism is the enormous volume of gas and steam emitted during eruptions. Advocates of a superficial origin regard the gases, and more especially the steam, as due to penetration of surface waters, *i.e.*, as secondary by-products. Those who incline to a deep-seated origin look upon them, and more especially the gases, as original constituents of the earth's mass; *i.e.*, as primary elements. The original nature of the gases, which are observed to burn as they burst from the lava, was a critical, unknown fact. Their burned products, such as steam and sulfur dioxide, could not be distinguished from atmospheric constituents. To know if they were primary we must catch them before they reached the air. And this could be done only at the surface of a lava lake, where the temperature is 2,000 degrees Fahrenheit. Difficult as that may seem, it was accomplished by A. L. Day and E. S. Shepherd in May, 1912, during a descent into the Firepit of Kilauea, during an active eruption. They were lowered over the vertical wall to the edge of the thin crust that covered the bubbling surface and they succeeded in drawing off original gases from within a lava cone. They were chiefly hydrogen and sulfur, which must have been oxidized instantly had they come into contact with the air. They therefore obviously had come from a source below the depth to which air or water could penetrate.[2]

The volume of gases which thus escapes and burns at the surface of the lava is but a small fraction of the total amount of steam and gas emitted. The larger part has been burned in rising through the upper few miles of rock, where oxygen is available, and burning in confined spaces it has produced the heat of a blowpipe. That is quite enough to melt rock. Thus it would produce lava.

[2] Day and Shepherd, *Bull. Geol. Soc. America*, 24: 573–606, 1913.

We are brought back to the consideration of a relatively superficial origin for some volcanic lavas, provided there be a source from which primary, so-called juvenile gases are supplied. That source can only be some spot in the lower part of the outer crust or in the upper part of the underlying mantle. And it must be a heated spot, a heated body of rock, because gases, although contained in all igneous rocks, remain fixed in equilibrium unless the temperature rises. Thus a volcanic eruption means that a mass of rock, situated at considerable depth, has been heated to the melting and boiling point, at which it expels gas; and the escape of the gases leaves it relatively cool and inert for a shorter or longer period.

The great variations in activity which are characteristic of volcanoes are thus traced to similar changes in temperature at a depth below the reach of any superficial reaction. The cause of changes is a condition of the interior, in a zone where theory assumes relatively constant temperature. What is the source of the variable heat energy? It probably is transmutation of atoms, especially radioactive generation of heat: appropriate in character, probable in that general zone, and adequate in amount. No other source that so fully meets all the requirements is known.

Reviewing these speculations we find that we have returned to the original inference, namely, that volcanic energy springs from a molten mass within the globe; but, whereas that mass was formerly supposed to comprise all the interior beneath a thin crust or to be represented by residual bubbles in the cooling sphere, it may now be regarded as a local hot body, which is chiefly heated by atomic (radioactive) disintegration. Vulcanism in any region may be thought to have been initiated when the molten body, rising from the depths, so nearly

reached the outer crust that gases might ascend to the zone of oxidation. The effect of their very high temperature plus the heat produced by their partial combustion is to melt the rocks they penetrate and so to form lava, which erupts, it may be quietly or explosively. In the meantime the deeply buried, heated body has lost its hottest constituents and subsides to a simmering state or becomes solid, though near the melting temperature. Volcanic activity becomes dormant or apparently extinct. But if the temperature of the source is again raised to the melting and boiling stage, the processes of vulcanism are revived. The source of the heat is in all probability that to which astronomers attribute the energy of the stars, the disintegrating atom.

The Japanese Archipelago is studded with groups of volcanoes. If the preceding picture of the origin of volcanoes be correct, we may reasonably think that there are hot spots beneath the islands or closely adjacent to them, but at some depth, presumably 25 to 50 miles or deeper. The inference seems good, but it is suggested by one line of evidence only. Are there any independent approaches? We might explore the heat-history of the islands, as it is recorded in the occurrences of volcanic and other igneous rocks.

In Japan there are active volcanoes, dormant volcanoes and extinct volcanoes. Among the latter are some which were high cones, but they have been eroded and their roots are exposed. They are relatively old, though geologically young. In general, volcanoes which may still be identified are not older than the Pleistocene (Glacial) period, though they may go back into the preceding Pliocene period. None has survived from the next preceding, the Miocene period, although lava flows attributable to volcanoes occur interbedded with sediments of that age. That carries us back twenty to thirty million years. Even more significant than the volcanic rocks are those which have risen forcibly from below in a molten state and have penetrated fissures in the outer crust. These intrusives, as they are called, may have been feeders of volcanoes, but they at least intruded the outer crust and there cooled, without reaching the surface. They are then regarded as branches of the deep-seated molten body and, especially when they consist of granite or related rocks, as having been part of that molten body or "magma" itself. Having solidified beneath the surface they have been pushed up and the covering rocks have been eroded. It generally has taken more than twenty million years to uncover them and they often date from very much older times.

The preceding explanation applies generally, in many parts of the world. In Japan there are igneous rocks of various kinds, which demonstrate the occurrence of hot spots beneath the islands during the last sixty million years and more. Not that any spot has always been hot enough to yield melted rock or to boil and give off gases continuously. The process is intermittent, the reheating very gradual, the intervals between epochs of eruptive activity have been of a duration of millions of years. But from the volcanoes of to-day back through the ages to the time when the great masses of granite which form so large a part of the islands were uptruded the sequence of heating, melting and attendant effects has been repeated in the terrestrial crucibles beneath the Archipelago.

The source of the heat energy, which accumulated until it caused melting, was dissipated in eruptions and attendant reactions, yet re-accumulated to produce later molten bodies, is involved in speculation and is attributed to different con-

ditions by geologists of diverse minds and experiences. Professor Daly of Harvard has listed a dozen ideas,[3] among which the speculative mind may wander seeking some fruitful thought. He who would distinguish truth from fancy should be guided by the discoveries of modern physics. The working hypothesis with which we here proceed to explore assumes the presence of radioactive minerals and recurrent heating by atomic bombardment, as has been stated.[4]

The effect of the process has been to build up the ridges which constitute the Japanese islands by the rise of molten rock masses from beneath the outer crust. Some of the bodies cooled beneath the surface and are known as intrusive, plutonic rocks; others have been remelted and have been erupted as volcanic rocks. The cold masses have been pushed up and worn down, exposing the once covered plutonics and forming sediments of various ages.

Recognizing that the islands have been thus built up of masses from many different sources, we may next examine the Archipelago to ascertain how the various parts are distributed and related to one another. It is as if we were looking at any building and inquiring how it was put together or what was its structure. What, then, is the structure of the Japanese Archipelago?

As may be seen on any map of Asia, the main Japanese island, Honshu, has the form of a curve, an arc, which reaches from the northern island, Hokkaido, to the southern one, Kyushu. Closer inspection, especially with reference to the relations to adjacent submarine basins, shows that the main island is not simple, but really consists of two separate arcs and a central massive body (See map).

[3] "Igneous Rocks and the Depths of the Earth," Chapter X, 1933.

[4] Bailey Willis, *Bull. Geol. Soc. of America*, Vol. 49, 1938.

It is necessary here to introduce a generalization regarding the structure of the earth's crust. The arc is a very common form of its features. It is especially characteristic of mountain ranges. And where two arcs meet, there is usually a massive, irregular bunch or knot of more or less mountainous character. Designating the arcs as *arcs*, we may refer to the knots as *nodes*. And we may say that the crust of the earth presents on its surface many arcs and nodes and the basins which they define. Perhaps we may learn why this is so, but however little we may understand of the constructive processes it is clear that the Archipelago comprises a group of typical structures of the crust of the globe.

Enumerating the parts of the group we may distinguish:

Hokkaido node, at the junction of the Karafuto and Kurile arcs and connecting with the Honshu arc.

Honshu arc, extending from the Hokkaido node to the Gifu node, the central body of the main island.

Gifu node, at the junction of the Honshu arc with the complex structure comprising the Tsushima and Shikoku arcs.

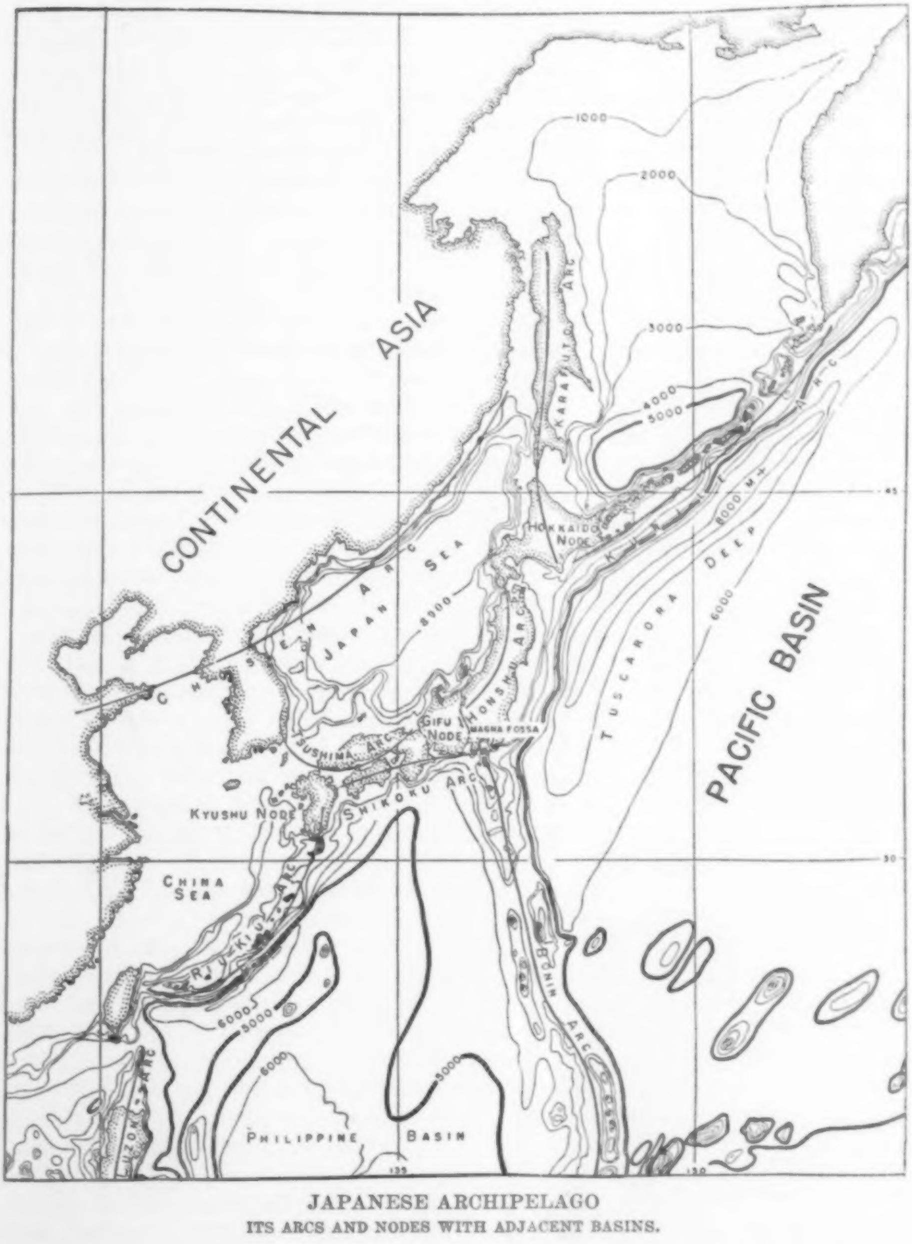
Tsushima and *Shikoku* arcs, which lie closely pressed together, but are convex in opposite directions.

Kyushu node, at the meeting of the Tsushima and Shikoku arcs with the Riu-Kiu arc.

Riu-Kiu arc, extending to Formosa.

Curiously enough and contrary to general assumption, the island of Formosa or Taiwan is not a part of the arcuate structure, but consists of the sediments of an ancient delta, probably that of the ancestor of the Yangtze River, which have been folded up into a mountain range. Thus Formosa occupies a gap in the succession of arcs that borders the Asiatic continent, which is continued southward by the Luzon arc and others of the Philippines.

These garlands of curving islands which drape the eastern coast of Asia enclose between themselves and the con-



JAPANESE ARCHIPELAGO
ITS ARCS AND NODES WITH ADJACENT BASINS.

tinent large water bodies, that in part occupy deep basins, in part submerge the continental margin. We are here concerned only with those which are related to the Japanese arcs. The most conspicuous of these on the map is the Japan sea, covering an oval that is roughly 400 miles across. Its depth over

a considerable expanse is at least 1,500 fathoms or that of the shallower oceanic depressions.

Another submerged area is that of the Yellow or Chinese Sea, which is bounded by the eastern coast of China, Korea and the southern Japanese islands. Though similar in area it contrasts strikingly with the Japan Sea in depth, being very shallow. The sounding line shows only 20 to 40 fathoms over most of its expanse. It is clearly a submerged part of the continental platform. And yet, just inside of the Riu-Kiu Island arc, there is a trough, which reaches depths of more than 1,000 fathoms and may be regarded as having been part of the oceanic basin.

Thus the Japanese ridge has risen through the bottom of the Pacific.

The so-called basin of the Pacific Ocean is not a single basin. It should not surprise us that the waters fill many hollows, if we remember that they cover nearly half the surface of the globe. The Pacific is often discussed as a unit in form, origin and history. It is far from being so simple in any respect. Abreast of Japan are two large basins, separated from one another by the ridge of the Bonin arc, which extends southerly from the Gifu node. To the west of it is the great sea which is called the Basin of the Philippines because it stretches down past the eastern islands of that group. It is 1,200 miles across and is of oceanic depth, 3,000 fathoms and more. Eastward and northeastward from the Bonin ridge extends the North Pacific, where soundings are too few to afford data for definition of minor areas.

The exposed points on the Bonin ridge are volcanoes. Hence we may infer that the ridge resembles the Japanese arcs in being of eruptive origin. The rock masses which form the ridge have also come up through the ocean bottom. On the south it adjoins other arcs that appear as the islands of Oceanica and like it have risen through the ocean bed. Is there not some condition which has determined this arrangement of eruptions in a pattern of arcs? Is it some peculiarity of the oceanic regions? Apparently not, for the same pattern is characteristic of the curving mountain ranges on the continents. Is it some manner of growth of segments of the earth's crust, like the plates of armor on a dinosaur? And if so, do the eruptions define the margins of discs that extend over hot spots?

This last is the best guess that I can now offer. I think that a hot spot or a group of hot spots may be from one to several hundred miles in diameter and hotter in some parts, cooler in others; that such an area has had a long history of development, of successive eruptions, which have built up the disc in the outer crust; that the disc has assumed a rounded form, such as is characteristic of molten bodies; that the main body has been cemented by repeated intrusions and has been rendered relatively impenetrable, so that later eruptives have migrated outward, under it, toward the margins, where they may solidify beneath the surface or remain hot enough to constitute local hot spots and give off gases to heat volcanoes.

We might proceed to test this speculation by a review of the eruptive history of the crust of the earth, but that would lead us far from Japan. Accepting it as a fair guess we may examine the basins around the Japanese Archipelago to see what relations they bear toward the island arcs. The Japan Sea fills a basin west and north of the Honshu and Tsushima-Shikoku arcs and is separated by the main island from the two larger basins of the Pacific, which are divided by the Bonin arc. The ridges of the Archipelago obviously constitute the rims of the basins, between which they rise

as high mountain chains. Their general altitude above the flat bottoms of the basins is 12 to 15 thousand feet. They consist of granitic and other igneous rocks, together with sediments which have been folded and crushed. In every respect of constitution and dynamic history they are mountain chains and may be compared with the ranges which encircle the continental basins of Asia. One can hardly doubt that they are results of the same forces and processes.

But though the mountain ranges of Japan resemble mountain ranges in general, the bases from which they rise are different in that they are submarine, not continental. The rock bottoms of oceanic hollows are unlike the plateaus of continents chiefly in the minerals of which they are composed. It is the difference that exists between basaltic and granitic rocks, between two slags, as it were, the one (basalt) containing more iron and magnesia with less silica in proportion, the other reversing these relations. How this difference originated is a problem involving the chemical and physical reactions in the furnaces beneath the outer crust, where melting and crystallization occur at varying temperatures and pressures, under conditions that we can not reach in laboratory experiments, though we may approach them. Our knowledge and its limitations are well stated by Bowen,[5] but however they may have been produced there is no doubt of the separation of the great volumes of granite as continents from the much greater volumes of basalt that constitute the ocean beds.

Now the ocean beds are exceedingly flat; no plate or saucer is as shallow or as smooth as the bottom of an oceanic basin. Continents by contrast are rugged, but we do find in them large areas which are flat, some of them because they were built that way; and they consist of flows of basalt. They are the areas of the so-called "plateau basalts." Just to cite one as an example, the Columbia and Snake River basalt plateaus of the northwestern United States have an area of some 300,000 square miles and when erupted were very flat. The lava lies in thin sheets, as it spread out after rising through fissures, piling up sheet upon sheet to a thickness of a mile or more. Evidently there was beneath that region a hot spot (or several hot spots, since the eruptions were not all of one age), in which the basalt melted or separated from a parent melt and from which it rose. This form of eruption differs from the volcanic, in which basalts build broad domes, like Mauna Loa in the Hawaiian Islands, and is known as fissure eruption. A third basin, that of the Sea of Japan, was formerly covered directly by waters of the Pacific, since the oldest identified rocks of Honshu are marine (Paleozoic) sediments; but even so it may have been formed over an independent hot spot, and considering its size it probably was. Its area is approximately 250,000 square miles and thus compares with those of the "plateau basalts." The uplift of the mountain chain that is represented by Hokkaido, Honshu and Kyushu has in more recent times separated it from the Pacific Basin.

Removing the waters from the seas we now have an idea of basins and mountain ranges and may see the Japanese Archipelago rising from the ocean beds as the mountain chains of Asia rise from the plateaus. In both regions, in the oceanic as in the continental, high ridges form the margins of rounded, flat areas; and in both, the elevated margins are crushed in such a way that it is evident they have been pushed up. Crushed is, perhaps, not the right word, for it suggests a disorderly mass of fragments; a mountain range is not a disorderly

[5] "The Evolution of Igneous Rocks," Chapter XVII, 1928.

mass; it consists of various rock masses, which assembled originally in a definite order and which have been moved into another, but still orderly arrangement. What looks like disorder, where rocks of different ages and different kinds occur seemingly jumbled together, is found to be orderly when we apply the laws of mechanics and deduce the action of the forces that have caused the rearrangement.

Perhaps this requires a little explanation. Let us recall an experiment made way back in 1797 by Sir James Hall of Scotland and described by him in 1812. He placed a thick pile of cloth on a table, loaded it with a heavy door, and then applied pressure to the pile of cloth, horizontally, so that he forced it into folds. Thus, said he, have the strata of rock, which may be observed on the coast, been folded up. He thought they must have been soft when folded, but in that he was mistaken. The hardest sandstones and limestones may be bent, provided they are so loaded that the rock can not break apart. In mountains we find piles of strata thousands of feet thick, originally laid down as flat as the sea bottom, the oldest at the bottom of the pile, but now folded, forming arches and troughs that are parts of mountains or mountain chains. We also find that the rock masses, particularly the massive, unstratified masses, have been sliced by pressure, after the manner which in mechanics is called shearing. They then appear cut into blocks by two sets of parting planes, and not infrequently the blocks are pushed past each other.

The attentive reader may have realized that the pile of cloth, when forced into folds by Sir James, had to slide over the table; and, if he continued pushing after it had folded up closely, it would move forward as a whole. The same displacement happens when a mountain range is pushed up. Whenever it becomes so rigid that it can more easily slide as a whole than fold or shear internally, then it advances. The Rocky Mountains in western Montana have thus been pushed out over the Plains at least seven miles, as may be seen in Chief Mountain, and similar displacements amounting to as as much as twenty or more miles are known in various parts of the world. But the bottom on which the mountain mass moves is not horizontal, as the table was, it is inclined, and the deeper roots of the range ride up on it, pushing out over more superficial, younger rock formations.

To illustrate: In south, central Chile the port of La Concepcion is on the coast and the town of Chillán is at the foot of the Andes, a hundred miles inland. On January 25, 1939, both cities experienced a severe earthquake, which to a less degree shook the intervening mountain country. The shock was due to a slip on the bottom of the coast ranges, which are being shoved eastward. A very similar, wide-spread disturbance occurred in north central Chile on November 10, 1922, and the nature of the quake-producing movements was studied in some detail. The conditions differ from those in California in that the elastic vibrations are started from a very gently inclined surface of dislocation and affect a large area severely, whereas in California they originate on a vertical plane and are strong only along the narrow strip where it appears at the ground surface.[6] In both regions the earthquakes are due to movements of mountain blocks on planes of dislocation, so-called faults, but in the Chilean type the fault is a *thrust* or *overthrust,* whereas the Californian is a *vertical shear* with *horizontal displacement,* which may be attributed to a rotational movement. Instead of being pushed up an incline, the mountain block

[6] Bailey Willis, *Carnegie Institution of Washington, Publication* No. 382, 1929, page 74.

in the later case turns, like a man in a dense crowd. We will find both types of faults in Japan.

Japanese geologists have during the past half century surveyed their country in detail. They have published excellent maps and have been generous in describing the facts to the foreign colleague, who could not read Japanese. My personal obligation to them is great. The geology of the islands has also been described and interpreted by foreign geologists, especially by the German authorities, Edmund Naumann, Ferdinand von Richthofen and Eduard Suess, and European thought has influenced the reasoning of Japanese students, who have studied in France, Germany or Switzerland. The several attempts to account for the peculiar form and position of the Archipelago have been excellently summarized by Professor Hisakatsu Yabe, of Sendai, who clearly points out differences of opinion and suggests modified views.[7]

All these discussions appear to share a defect that is common to many geologic speculations in that they fail to discover any force adequate to perform the stupendous work of mountain-building or to explain how the observed structures can have been produced, consistently with the principles of mechanics that govern the processes of rock deformation. We may, perhaps, frame a more workable hypothesis if we first postulate the action of a known, competent force and then show that it can be harnessed in such fashion that it will cause (or has caused) the demonstrable displacements of the crust.

Let the assumed force be that which resides in crystal minerals, where it holds the atoms to their stable relations.

Let there be disturbance of those stable relations by heating in the presence of chemically active liquids and gases; the heat being attributed to radioactive degeneration of atoms by those slow processes that generate heat energy.

Let us assume that the generation of heat by radioactive processes proceeds in a limited mass of rock situated beneath the outer crust (at depths not less than 25 miles or more) and that it there produces a molten bubble, which grows slowly and is encompassed on all sides by solid, crystalline rock.

Let the development of these conditions endure for some millions of years.

Let it be understood that crystals tend to adjust themselves to their environment by such changes of constitution and form as may produce a mineral or minerals better balanced under changing conditions of temperature and pressures. In other words, they undergo metamorphism. And, furthermore, when the change involves an increase of volume or the transformation of granular forms into elongated ones, then the growth exerts a force that may become equal to the crushing strength of the crystal.

Let it be further understood that the law of least resistance directs the growth of any crystal which is elongating in such manner that it must grow longer in the plane at right angles to the greatest pressure and in the direction of the least.

Let us accept the following conclusion: At the assumed depth of 25 or more miles the weight of superincumbent rock exceeds the crushing strength of the rock on which it rests. It is supported, therefore, only in part by that strength. The stability depends upon the lateral support or horizontal pressure of any mass against the adjacent one. But since the strength holds up some of the weight, the horizontal pressure, under conditions of stability, must be less than the vertical pressure. Consequently, if any crystal in that environment undergoes a change of form involving elongation, the direc-

[7] H. Yabe, in *Science Reports of the Tohoku Imperial University*, Sendai, Japan, Second Series (Geology), Vol. IV, pp. 70–104, 1915–1918.

tion in which it must grow, as determined by the law of least resistance, will lie in a horizontal plane; and in that plane it will be toward the weakest side.

From these considerations we may deduce a force which would be the resultant of an infinite number of crystal growths and which would exert a pressure in a definite, radial direction. Each atomic adjustment would exert a stress equal to the crushing strength of the mineral and the sum of any number of of them, acting in unison, would exceed the crushing strength of opposing rock. The latter must, therefore, be displaced. The action might become effective within the expanding disc or it might push out the surrounding frame. Since the increase of any dimension of a crystal undergoing metamorphic change may amount to two or several times its original length, the sum of elongations in a layer ten to one hundred or more miles across may attain the proportions reached by displacements observed in mountain ranges.

These are the assumptions and the reasoning of the hypothesis known as metamorphic orogeny, or mountain building, through recrystallization. How may it stand the test of explaining the structure of the Japanese Archipelago?

The mountain ranges of Japan are young, as is shown by the sharply incised canyons and valleys, which characterize the scenery of the uplifted blocks. They are indeed growing, being pushed up or turned by unbalanced pressures, as is demonstrated by the frequent elastic jumps that we call earthquakes. There are also many volcanoes, whose activity, as we have seen, may be attributed largely to hot gases rising from molten bodies. Thus the mountain-building pressure appears at the present time to be contemporaneous with the existence of hot spots in the same general part of the earth's crust. This relation has existed for some twenty million years or more, for the process of uplift and the volcanic activity may be traced in mountain forms, in sediments and in lavas back to the Miocene or middle Tertiary age, which is that far back. It is a long time and we may not assume that any terrestrial process has progressed steadily or continuously throughout the ages; but heat and pressure have been actively developed and dissipated in the one great structure, the Japanese Island arcs, during the last twenty million years.

Nor was this the beginning. The same activities have gone on side by side or in the relation of cause and effect since at least one hundred million years ago. The earliest event that has been identified in rocks now exposed at the surface was the intrusion of bodies of granite into the outercrust. They were uptruded from hot spots, which had presumably been heating up during a preceding age. Beginning in the Lower Cretaceous the intrusions arrived near the surface from time to time in a succession that continued through the thirty million years of Upper Cretaceous time and into the Eocene or early Tertiary. If the entire mass of all the granite bodies was originally molten before the first uptrusions began, then the successive intrusions may have been practically continuous. But that is improbable. It is theoretically more reasonable and also more in accord with observed relations to infer that the hot spots heated up gradually, lost the molten body when it became large enough to rise, and were reheated by their remaining radioactive elements. The process was intermittent. During the intervals sediments accumulated in basins and troughs on the surface and they, together with the intruded granite bodies, were compressed during repeated mountain-building episodes. The details of the prolonged sequence of events have not yet been deciphered and may never

be entirely, for the folding and shearing produced during any one orogenic movement becomes obscured by the next.

However simple or complex the history may eventually prove to have been, the general fact is that melting, intrusion and mountain-building are the activities by which the Japanese Archipelago has been constructed during the last hundred million years.

Pursuing our inquiry into the relation between hot spots and the sources or centers of pressure, we may try to place them. If on independent evidence they should be found to have originated in the same parts of the crust, the inference of a causal relation would be strengthened. There are two questions: Where did the granitic intrusions come from? and in what direction, from what region were the pressures exerted?

Regarding the granites the evidence of origin is most apparent in southwestern Japan and southern Korea. Granite bodies are numerous in the Tsushima arc and in the adjacent part of the peninsula, and they are chiefly of Cretaceous and early Tertiary ages. The zone of intrusions surrounds the southwestern lobe of the Tsushima Basin, a part of the basin of the Sea of Japan. The position may be an accident, but if, as seems logical, there is a reason for it we may infer that the arc, so far as it extends, defines the outer rim of the disc and that the paths of the intrusions in rising to the surface were governed by the form of the disc. The direction of the paths in approaching the surface was probably nearly vertical, but there is good reason to think that the molten rock followed lines of least resistance along the under side of the disc and up inclined shearing planes, before it turned more directly upward. Its source then should be located under the adjoining section of the Tsushima Basin.

The orogenic pressure which has repeatedly folded the sedimentary rocks of southwestern Japan and sheared the massive granites has acted consistently in a north-south direction. The rocks of the Tsushima arc are most intensely crushed, displaced in large masses and pushed over, one sheared-off sheet upon another. The whole arc is pushed southward upon the Shikoku arc and one of the great features of the structure of Japan is the so-called "Median Line," an overthrust of older rocks upon the Cretaceous, throughout the stretch from western Kyushu to the Gifu node. The push carried the northern sheet over the southern mass.

We may infer that the source of pressure was in the Tsushima lobe of the Japan Sea disc, over the probable source of the molten granites.

The case for the Honshu arc is very similar, but it introduces also another line of reasoning, of peculiar interest.

Granites in the Honshu arc occur chiefly in two zones, an eastern or outer, and a western or inner zone. Those of the outer belt are assigned to the Lower Cretaceous age; those of the inner may in part be of the same general antiquity, but may include some of later, possibly Tertiary date. Whatever their periods, there is nothing in their distribution to indicate their source, as there is around the Tsushima lobe. They may have come up directly or from under either the Japan Sea disc or the Pacific Basin. There is, however, a suggestion.

Upon the Pacific side the ocean is exceedingly deep. The trough of the Tuscarora Deep sinks a thousand fathoms below the general level of the nearby ocean bottom, to something over 4,250 fathoms. It stretches from abreast of Honshu northeasterly past the Kurile Islands and is characteristically long and narrow. Its form distinguishes it from the oceanic basins, which are typically broad and relatively shallow. Else-

where I have called attention to this difference,[8] and I attributed the subsidence of a narrow strip of the crust, in a region where there is evidence of igneous activity, to the collapse of a portion of the wall of a magma reservoir. The wall would stand so long as it was supported by the hydrostatic pressure of the molten volume, but it would slip inward at the base and sink down if that volume were reduced by eruptions. At the surface the effect would be to develop a trough, due to subsidence. The Tuscarora Deep bears the appropriate relations to a region of igneous activity and the inference regarding its origin accords with all known facts and with the principles of mechanics that should govern such a failure of the crust. We must, however, note a caution. The Tuscarora Deep is as young as the mountain ranges of Japan, to judge by the fact that it has not been filled with sediment. If it was initiated during the uptrusion of the Lower Cretaceous granites of eastern Honshu, it must have been deepened during the later, Tertiary eruptions. Any inference we may draw from it is, therefore, restricted to that relatively recent period.

If the Tuscarora Deep be due to collapse of the wall of a magma basin, the basin should lie to that side of it where the eruptions have occurred, in this case toward the northwest. And, since the Tertiary granitic intrusions and eruptions of rhyolitic, dacitic and andesitic rocks have occurred extensively in the western, inner zone, its locus should be sought under that side or under the adjacent area of the Japan Sea Basin.

As regards the direction and effect of orogenic pressure in the Honshu arc, we have an interesting study of the shortening of Tertiary strata, a map by Yanosuke Otuka, which shows that along lines radial to the arc the compression has amounted to as much as 8 or 10 per cent. and locally even to 34 per cent. of the original width. That is to say, any section which was originally 100 miles wide has been reduced to 90 miles or less by orogenic pressure. The stress acted from the Japan Sea Basin outward, toward the southeast, that is from the inferred locus of the hot spot.

We have still to consider the Gifu node, especially with reference to the displacements it may have suffered. It is a massive block of Paleozoic sedimentaries, which have been metamorphosed by very large intrusions of Lower Cretaceous granites and other igneous rocks. It is roughly a hundred miles square. The southeastern and southwestern corners are traversed by great faults, which have the character of fractures due to twisting, as if the mass had been turned in a clamp. And its eastern boundary is a fault zone of marked displacement, known as the Fossa Magna of Japan.

The Fossa Magna is a crushed zone, which runs across Japan, in a north-south direction between the Honshu arc and the Gifu node (see map). Known since more than fifty years ago, it has been discussed by all students of the geologic structure. Its true character becomes apparent when it is recognized that the general movement along it has been a slipping of the western block, the Gifu node, past and eastern. This is shown by the horizontal striations, where one mass has scored the face of another, and the displacement has been southward on the western side. There are, of course many minor, though in themselves large, structures, both of folds and faults, which are due to pressure of the great twisting block against its neighbors, and the attempt to force these local developments into some theoretical mold of Asiatic mountain systems has resulted in unfortunate controversies. But the rota-

[8] *Carnegie Institution of Washington, Publication* No. 470, page 183, 1936.

tion of the great block of the Gifu node in a clockwise direction is a fact.

The direction of stresses, which might produce this rotation, should be directed diagonally to the Fossa Magna, toward the southeast, and they would originate in the area of the Tsushima lobe of the Japan Sea Basin.

Thus the examination of the three sections of the Archipelago, the Tsushima-Shikoku arcs, the Gifu node and the Honshu arc, leads us along various lines of evidence to the conclusion that the southern and southeastern parts of the Japan Sea disc have been the loci of hot spots and also the sources of orogenic pressures, both activities having been effective from time to time during the past one hundred million years.

Heat and pressure react upon one another and cooperate to produce a number of geologic phenomena in a variety of ways. Their reactions form the subject of many theories. Here we have a situation, however, in which the result of their action upon crystalline rocks, underlying a heavy load, over a heating mass, throughout an extensive region, during millions of years, can not have failed to cause recrystallization of the type which is characteristic of the "Archean" terranes of Canada and British Columbia, as well as of other countries where very old rocks are extensively exposed. Being so old, the gneisses and schists have been very deeply eroded and their structures may be observed. The rocks consist of flattened, elongated crystals, lying in horizontal or gently inclined attitudes. They have been recrystallized from igneous rocks of original granular texture and the change of form has been accompanied by expansion with great force, as may be seen in the roots of the mountain ranges that once rose along their margins.

Is it not reasonable to infer that the mountain chain which constitutes the Japanese Archipelago is similarly an effect of the heating up of hot spots and the consequent metamorphism of the overlying crust in the region of the southern Tsushima Basin?

If that question meets with an affirmative, even though provisional answer, are we justified in extending the inference to other regions, where mountain arcs border plateaus that consist of successive igneous intrusions to continental Asia, for instance, as suggested in "Growth of Asia" and "Wrinkles of Asia?"[9]

[9] SCIENTIFIC MONTHLY, June and November, 1939.

GEOLOGIC DATING OF HUMAN EVOLUTION IN ASIA

By Dr. HELLMUT DE TERRA

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LATELY we have received new and abundant information on Fossil Man in Asia, which should be interpreted in the light of Pleistocene geology in order to approach a solution of the problem of dating the extinct races of Man. The new skulls and skull fragments of *Pithecanthropus* found recently in Java, the many fossil remains of *Sinanthropus*, the Peking Man, unearthed from a limestone fissure near Peking, and the many thousands of stone tools collected from the Siwalik Hills in India down to the Dutch East Indies, all these new finds make possible a new approach toward the problem of human origins in Asia. Above all other considerations stands the necessity of establishing a chronologic basis for the morphologic sequence of extinct human types.

On my various travels to the sites of Early Man in Asia no problem seemed more urgent than this age question of Fossil Man. To solve this problem we need a great many data on the geologic formations which contain traces of early man. Such data have been collected from North China, Burma, India and Java, and all that is required now is to find a method which will enable us to correlate these data and integrate them into a coherent picture of the ancient world from which rose the dominance of Man over all other mammals. Indeed, if we could find a geologic way of dating the various finds, many hitherto unused and seemingly unrelated data would acquire new significance.

At present the chronology of Fossil Man in Asia is based chiefly on paleontology. In the case of *Sinanthropus* a great many fossils were unearthed with the human bones, and from them we receive a picture of the Pleistocene mammal fauna with which Peking Man appeared. Horse, straight-tusked elephant, buffalo, rhinoceros and deer, and a great many smaller mammals indicate a modern fauna, such as that which roamed over the temperate steppe and forest lands of Asia up to the close of the Ice Age. The majority of these animals were ruminants dependent on good grazing such as is not found any longer in the vicinity of Peking. The Peking Man fauna contrasts with two other fossil faunas, one of which is found in strata lying beneath the famous "yellow earth," or loess, of North China, while the other is intimately associated with the latter formation. The older fauna also is found in beds of loessic origin, as G. B. Barbour has shown. He called this older stage the "Sanmenian," and its fossil fauna is generally known as "Nihowan," from a locality in North China. There is in it a greater percentage of extinct genera, as compared to the Peking Man fauna, and there is a distinct correspondence with the "Villafranchian" fauna of Europe, which is generally considered to be of Upper Pliocene age. The loess fauna proper has mammoth and bison, and with it appears a type of fossil modern man who chose to settle right above the abodes of his progenitors, namely, one story higher up in the caves near Peking. If, as Teilhard de Chardin has lately suggested, the Nihowan fauna of North China is of Early Pleistocene age, then we have three distinct Pleistocene divisions as based on vertebrate fossils.

Such a threefold division of fauna we

might correlate with that found in lands south of the Himalayas. Following the late W. D. Mathews' suggestion, we would consider the Upper Siwalik fauna of India as marking a new wave of mammal migration from North America and Europe coincident with the Early Pleistocene. The second division would be represented by the combination of elephant, hippopotamus, horse, deer and buffalo, such as occur in the alluvial deposits of central India (Narbada- and Godavari rivers). As in China, this fauna is associated with early man of whom no other traces but well-made implements have so far been found in India. A third Pleistocene fauna would be represented by the cave fauna of Karnool in Southern India, where prehistoric bone industries abound.

Between India and China we would find a similar sequence of fossil faunas. In Burma, at least, are indications of a Lower, Middle and Upper Pleistocene mammal assemblage.

For Java, von Koenigswald has been able to differentiate between three Pleistocene faunas which he called Djetis-, Trinil-, and Ngandong. The second of these is characterized by *Pithecanthropus erectus* Dubois, while the latter is associated with neanderthaloid remains of Solo Man (*Homo soloensis neanderthalensis* Oppenoorth).

These areas embrace the region where to all appearance Man evolved into various races during the Pleistocene. It is an enormous terrain where fossil localities are scattered far and between. Moreover, the Pleistocene embraces a total time span down to the present of about 600,000 years, during which the fauna could adapt itself to environmental changes as it did in other parts of the world. Hence some of the paleontologic distinctions may be artificial. In fact, in Java there is a distinct transition between the Trinil- and Ngandong faunas, the latter differing from the *Pithecanthropus* fauna by very few types only. Also, there is no "cold" or "warm" type of fauna as there is in Ice-Age Europe. All this makes a formidable handicap for computing a reliable chronology of the Pleistocene, and the fact that fauna changed only twice during this period is sufficient reason for improving our stratigraphic methods in dating ancient man.

The type of stratigraphy that we need should fulfill three main expectations: (1) age determination of fossil human remains; (2) correlations of Pleistocene strata and their cultural records, and (3) reconstruction of environmental conditions.

A New Approach toward Pleistocene Stratigraphy

The Pleistocene is one of the few geologic periods known to have had a cyclic history which we find documented rather clearly by geological deposits over very wide areas. From the Pyrenees and Alps in Europe to the distant Himalayas, and from the Canadian plains to the Sierras of South America, reach our known records of what has so aptly been called the "glacial cycle." In many areas, such as the Alps, the Caucasus, the Himalayas and in North America, four glaciations and three interglacial periods are known. In other lands the records are less complete, but here also evidence is accumulating that the glacial cycle made itself felt in regions at, or south of, the equator. The theory of multiple glaciation has world-wide validity. This fact should be the cornerstone for any Pleistocene stratigraphy no matter whether we have to deal with glaciated or unglaciated terrain. For, if the climatic changes were world-wide, their effects upon sedimentation and relief-making processes must have been of world-wide extension.

As far as Asia is concerned, glacial cycles have been studied in some detail in the Pamir, Karakorum and Himalaya, which ranges constitute the backbone of

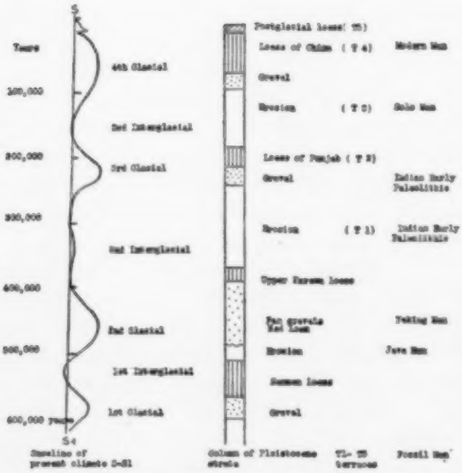


FIG. 1. SUGGESTED GLACIAL CHRONOLOGY IN ASIA

the high Asiatic massifs. Glacial phenomena have been reported from the Tienshan, Alai and Richthofen Mountains, and more recently they have been recorded in the Yangtze drainage. In none of these regions are the data as complete as in the western Himalaya, especially as here the glacial formations merge with the piedmont deposits containing mammal faunas. For this reason it seems justified to use this area as a reference region for the lands lying south and east of the Himalayas.

The stratigraphic approach described hereunder is based on field studies made on two journeys to India and Southeastern Asia. Chief assumptions made are: (1) that the climatic cycle of the Pleistocene was caused by world-wide changes of temperature causing pluvial and interpluvial phases in the non-glaciated regions; (2) that the approximate time span of the Ice Age embraces some 600,000 years, a figure based largely on the solar radiation theory of Milankovitch, and (3) that changes of climate are recorded in special soils and sediments which may under certain conditions serve as climatic indicators.

Obviously, an appreciation of the climatic cycle presupposes a conception of temperature fluctuations in the Himalayan region. These were computed as indicated in Fig. 1 on the basic assumption of F. Klute (1928) according to which the present position of the snow-line[1] corresponds to present climatic conditions, as the last glacial snow-line corresponds to the last glacial climate. The temperature fluctuations in the western Himalayas were computed from the varying positions of snow-lines during the Ice Age, from the paleobotanical, paleontological and sedimentary nature of Pleistocene formations.

For the first Himalayan glaciation (600,000 years ago) we calculated a depression of snow-line by 1,600 meters, which corresponds roughly to a lowering of mean annual temperature of 8° C. (at 33° N. latitude). During the First Interglacial, climate was warmer in the Kashmir region than it is to-day and somewhat more moist, as indicated by the spread of the pine-oak forest toward the inner Himalaya (de Terra and Paterson, Carn. Inst. Publ. 493, 1939). At that time temperature rose to about 1.5° C. on the annual mean. For the second glaciation (450,000 years ago) a depression of snow-line by 1,500 meters was already calculated by Dainelli (1922), which corresponds to an approximate drop of temperature by 7.5° C. as compared with the recent period. During the long Second Interglacial (280,000–400,000 years ago), the climatic optimum may have been similar to the present, though there were minor fluctuations as recorded by varves in Upper Karowa clays. We know that the beginning of this Interglacial was relatively dry because dust storms carried great amounts of silt from the piedmont region into the valleys. The Third Himalayan Glacial (225,000 years ago) calls for a depression of snow-line by 1,400 to 1,500 meters, or a temperature drop of 7° C. At that time the advance of valley glaciers was

[1] The snow-line is the upper level at which the snow melts.

SEARCHING FOR STONE IMPLEMENTS ON A GRAVEL TERRACE IN INDIA

TWO STUDENTS OF EARLY MAN MEET AT THE MONUMENT OF JAVA MAN
NEAR TRINIL, IN JAVA. PÉRE TEILHARD DE CHARDIN AND DR. VON KOENIGSWALD.

enhanced by a preceding steepening of valley gradients due to mountain uplift. No data are available for the last Interglacial, but we may safely assume that it was somewhat drier and warmer than the preceding Interglacial because of the relative paucity of grazing animals in the adjoining plains from which larger ruminants, such as the elephants and buffalos, had already retreated. In Europe, also, the last interglacial climate is considered warmer than the present, as inferred from the floras of Pont-à-Mousson (France), Cannstatt (Germany) and Pianico-Sellere (Lake Ivrea, Upper Italy). The last glaciation in the Himalayas was accompanied by a drop of snow-line of 900–1,000 meters, corresponding to a temperature drop of 4.5–5° C. There were three cold subphases as recorded by terminal moraines. From then on a gradual rise of temperature may be assumed, though it must have been interrupted by one or two brief reverses in postglacial time during which the snow-line dropped to as much as 600 and 400 meters, respectively, leading to one or two brief ice-advances.

Influence of Climate on Sedimentation

The first question that arises concerns the nature of the sedimentary composition in the plains region, because if there is correspondence between glacial and non-glacial deposits we may expect that such is the case practically everywhere in lands adjoining the Himalayan highlands. From Fig. 1 it would seem obvious that there is close correspondence between glaciation, gravel accumulation and pluvial conditions in the non-glaciated region.

As to the correspondence of glaciation and alluviation, T. T. Paterson and I (Carnegie Inst. Publ., No. 493) have shown that in the case of Kashmir the glacial gravels can be traced for long distances into the neighboring lowlands of India. Especially the fluvio-glacial gravels of the second glaciation make very conspicuous fans at the outlet of the Himalayan transverse valleys. These fans show themselves uniformly dissected and the valleys are filled with a younger gravel which is capped by loess. This deposit can be correlated with the third ice advance, and the terrace belonging to this phase was traced up to the terminal moraines in southern Kashmir. The Third Interglacial was a phase of erosion, as was the preceding Second Interglacial, so that when glaciers later advanced a fourth time the melt-waters carried their load into these younger valley cuts. There is, then, a clear rhythm of deposition to be noted in this area which is chiefly a function of climatic changes. Successive uplifts can not produce such close correspondence of gravel terraces in the glacial and non-glacial regions. There is, for instance, the same succession of gravels and terraces in Burma, over 1,500 miles distant from the Kashmir region. My most recent observations in the Irrawaddy Valley, in Burma, have shown that this correspondence exists in regions lying some 400 miles distant from the glaciated tract. In such cases it is necessary to ascribe greater power of transportation to the streams of the Pleistocene descending from the glaciated highlands, because not only are the gravels coarser than any laid down in post-glacial times, but they are much thicker and usually connected with soils suggestive of heavier rainfall.

Such a process of alluviation can not be explained solely by the melting of snow or glaciers in the highlands, because at that time water was actually still locked up in the form of ice, and rainfall may well have been less in the mountains. Also, the melting of glaciers is not a catastrophic process which enhances stream power, but a very gradual waning which may lead to local accumulation of débris (outwash fans) but never to formation of shingle sheets trailing for hundreds of miles away from the ice-

bound highlands. The formation of such enormous gravel sheets demands specific conditions of climate.

Such conditions evidently corresponded to glaciations and may well be pictured as pluvial periods. Increase of rainfall was a sequential effect of the lowering of temperature because of the refrigerated air masses resting over the snow-bound Himalayas and over other ranges to the east. These uplands comprise some two million square miles of which at least 60 per cent. were covered under ice and snow during periods of glaciation. Cold air rested over these highlands, and barometric "highs" must have been more common then. No doubt the monsoon wind blew against this cold land and created cyclonic conditions which caused condensation of moisture. At such times precipitation must have been greater than nowadays, and therefore we can speak of pluvial periods, as far as these piedmont and plains regions are concerned. Slope streams must have been choked with débris because of intensified nivation, frost-action and glacier outwash. Frequent and torrential rains carried this excessive load into the plains where it spread out in the form of fans which subsequently coalesced, forming wide marginal gravel belts. Such alluviation was increased by occasional subsidence of the plains country; at places these gravel sheets are several thousand feet thick. Another factor that aided in the formation of these gravels was the removal and redeposition of great masses of half-consolidated coarse sediments, such as abound in the Siwalik Hills, as well as in the piedmont regions of Central Asia.

Obviously, in these regions it should be possible to recognize three to four gravel zones and the three erosion periods which mark the interglacial or interpluvial stages. But these gravels might by chance appear in similar successions in areas lying thousands of miles distant from one another and still owe their ori-

ICE-AGE GRAVEL OVERLAIN BY LOESS CONTAINING PALEOLITHIC TOOLS
SOAN VALLEY, PUNJAB.

WHERE ELEVEN SKULLS OF NEANDERTHAL MAN WERE FOUND
NGANDONG TERRACE, NGANDONG, SOLO RIVER, JAVA.

gin to different climatic or mountain-making conditions. Such uncertainty, however, might be eliminated if we consider the soils that go with these gravels.

The Climatic Conditioning of Soils in the Pleistocene

Vast regions in China, central Asia and India are covered by Ice-Age soils such as loess, loessic siltstones and red earths, which in most cases are closely associated with gravels. In Kashmir and the Punjab and in certain regions of Sinkiang (Chinese Turkestan) there is close connection between the last glaciation and loess deposition. In India the Potwar loess is Third Glacial, and in Burma there is a loessic silt belonging to the fourth terrace, which corresponds probably to the last glaciation. G. B. Barbour has shown that in China loessic beds occur in the Sanmenian stage (Upper Pliocene or Early Pleistocene). This would clearly argue for an Early Pleistocene Age, a conclusion which is equally justified in the case of Burma and India. Here the Upper Siwalik and Upper Irrawaddy siltstones contain many glacial clays. These earlier loesses are compact and always in tilted position, while the younger loesses are loose and rarely disturbed by later mountain making.

In fact, taking into account all the evidence on loess and loessic deposits, it would seem as if there were four of these glacial eolian soils, for in the case of Kashmir the "Upper Karowa beds" mark a period of late Second Glacial and Second Interglacial dust storms, adding another loess to the three kinds already mentioned.

A second type of soil which we might use as climatic indicator is found in a group of tropical and subtropical soils, such as laterites and red loam. Very often, as in Upper Burma and in South China, these are found with pluvial gravels. They distribute themselves in such

a fashion as to suggest changing periods of greater and lesser rainfall. In some cases, as in the terraces of the Irrawaddy in Upper Burma, the ground-water laterites are invariably associated with stages of alluviation; and since these correspond in type and number to those found in the glaciated tracts of the Himalayan Highlands, I suggest that they represent the precipitates of a pluvial climate. It is to be noted that such fossil laterites occur down to 20° latitude in regions which are known as "dry belts," with precipitation less than thirty inches a year.

There are other soils in these piedmont lands which are called "kankar," planosol or concretionary hard pan soils. In Burma these soils are conspicuous on surfaces having undergone prolonged weathering under drier climatic conditions. Very often they are buried deeply under younger alluvial and eolian formations.

A special type of soil is found in the more humid highlands of the Shan States and Yunnan. These are lateritic fans and red loams that appear associated with karst relief. These soils, especially the boulder fans, are often connected with cave and fissure deposits containing a Middle Pleistocene type of fauna (*Stegodon orientalis, Elephas namadicus*, orang, porcupine, deer, etc.). The famous gem-bearing gravels and sands of the Ruby Mines District in Upper Burma belong to this category. Similar soils from Kwangsi and Szechwan provinces of China have been described by J. Thorpe. Quite possibly their extension is greater than we know now. In Malaya the tin-bearing alluvium is associated with such fossil soils, indicating heavy erosion under pluvial conditions.

The correlation of these fossil soils with glacial deposits makes an interesting and important problem for Pleistocene

SITE OF MODJOKERTO WHERE MOST ANCIENT HUMAN FOSSIL WAS FOUND
EAST JAVA.

PITHECANTHROPUS SITE, SANGIRAN, JAVA, WHERE SKULLS WERE FOUND
ONE SKULL WAS DERIVED FROM THE UPPER LEFT SCAR ON THIS SLOPE.

geology. At the moment we can not say more than that the glacial gravels merge into pluvial (or fluvial) formations in the piedmont and plains regions, and that the glacial cycle is thus clearly documented over areas lying beyond the glaciated tracts. This correlation becomes more significant still if we view the terraces of Central and southern Asia as a whole.

Influence of Climate on Terrace Formation

Previously I have shown that the river terraces of southern and Central Asia show a surprisingly uniform pattern.

As for Central Asia, E. Huntington had ascribed the gravel formations to the erosive effects of dry periods during which soil wash proceeded rapidly because of prevailing aridity. The studies of Dainelli, however, on the glacial terraces of the inner Himalaya, and those made recently by Paterson and me give proof of the synchronous formation of glacial débris with Pleistocene gravels. This holds especially for the aggradational terraces II and IV of our system, while terraces I and III are of interglacial origin.

Under the conception of pluvial stages being concomitant with glacial stages (at

least, as far as the areas under discussion are concerned), it is not surprising that the same terraces should be found over regions covering thousands of miles in a west-easterly direction. In fact, between the Indus and the Yangtze Rivers this relation seems to prevail throughout, though much work remains to be done in intervening areas. The terrace sequence here found is characterized by five terraces, of which four are Pleistocene and one of post-glacial age, the oldest and highest being superimposed on gravel fans which are younger than the tilted beds containing Villafranchian fauna. In the glaciated regions, TI is of Second Interglacial Age; terraces two and four mark stages of heavy alluviation corresponding to the third and fourth glacial (or pluvial) stages.

It is possible that a similar system of ancient stream levels exists on the middle Yangtze, as G. B. Barbour's studies suggest. Huntington has described five terraces from the piedmont regions and basins of Eastern Persia which may well correspond to our sequence. Confirmation of this would enhance our chances greatly of viewing the Pleistocene in these areas under the conception heretofore presented.

But the Pleistocene column has other characteristics which are almost equally common to all the regions mentioned: the erosional and structural breaks of the sequences. The largest of these is found between the beds with Villafranchian fauna and the Later Pleistocene. This angular unconformity is almost universally found from the Caucasus to Central and eastern Asia. Other breaks are found between the gravel fans and the loess, and in northwestern India even the loess was slightly effected by subrecent mountain making. Uplift during the Pleistocene amounted to 6,000 feet and more, and the total amplitude of crustal deformation in the sub-Himalayan ranges exceeded 12,000 feet. It is this factor which may account for the local thickness of the Pleistocene in the piedmont region.

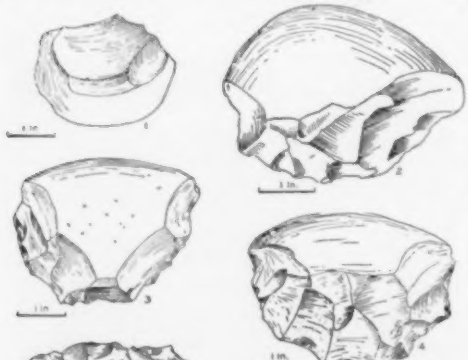
It is evident that the terrace sequence and the gravel zones enable us to divide the Pleistocene into more subdivisions than the paleontologic method can provide. Generally we can distinguish between four gravel zones and three major structural breaks in the sequence and, in addition, we have the five terraces and the soils which help to distinguish the pluvial from the interpluvial phases. It is interesting to see how this new stratigraphic scheme helps to clarify certain data on human origins in Asia.

Fossil Man and the Pleistocene Cycle

Under the conception of climatic changes, the phenomena of cave and fissure formations bearing human relics become more understandable. It explains the association of limestone caves, middle Pleistocene fauna and fossil man. Apparently the impact of the second

PEKING MAN, CHINA
AFTER RECONSTRUCTION BY F. WEIDENREICH AND SCULPTURE BY MRS. L. SWAN.

major Pluvial on the subtropic and tropic regions fostered existing karst formation in the limestone areas of China, Indo-China and Burma. In all of these areas a post-Villafranchian fauna appears intimately associated with fissure and cave deposits, such as at Choukoutien, the famous *Sinanthropus* site. Evidently ruminants were frequently trapped in sinkholes; in other cases, beasts of prey or even primitive man carried their victims to underground places or rock-shelters where they were subsequently buried under weathering products. Climate then was generally more moist in the peripheral regions, for in the plains of North China roamed buffalo, deer, antelope and elephant, a fauna which is quite unthinkable under present-day semi-arid conditions. We know that Peking Man himself hunted deer, for almost 70 per cent. of all fossils uncovered at Choukoutien belong to that family. Greater intensity of erosion due



OLDEST STONE-AGE TOOLS
FROM PLEISTOCENE GRAVELS OF NORTHWEST INDIA (SOAN CULTURE).

to pluvial conditions are indicated also by the thick piles of sediment which accompanied the karst formations. Under its impact land was wearing away rapidly and karstification took place on an unprecedented scale. Even outside of continental Asia similar conditions must have prevailed. In Java, along the Solo River, we find the remains of *Pithecanthropus* in alluvial sands that indicate intensive erosion and deposition. The fossil plants collected from these beds by the Selenka Expedition in 1907 were interpreted as indicating a slightly cooler and more moist climate than the present. In the neighboring karst of the Zuider Mountains are found the red loam formations with "Sino-Malayan" fauna (von Koenigswald, 1939), which also is of Middle Pleistocene Age. To me it seems most probable that Java Man lived at the time of the Second Pluvial, just as Peking Man existed during the early Middle Pleistocene, which corresponds to the second glaciation (perhaps 400,000–500,000 years ago).

Another interesting aspect concerns the distribution of Stone-Age tools. No paleoliths of good workmanship have been found in deposits antedating the second glaciation, or Second Pluvial. In the Siwalik Hills of the Punjab, as well as in Upper Burma, in North China and in Central Java the first real tools of man appear associated with a post-Villafranchian fauna in strata resulting from pluvial or greatly accelerated conditions of erosion. This was the fan-building stage. Extensive gravel fans spread throughout the piedmont lands and provided Early Man with the incentive to experiment with stone. The industry of Choukoutien and the coarse, quartzite flakes of the Boulder Conglomerate in northern India, as well as the crudely worked pebbles and flakes of the highest terrace gravels in Burma, all bear the stamp of experimentation rather than of established flaking tradition. Because of their close association with Peking Man

JAVA MAN
(PITHECANTHROPUS SKULL IV FOUND BY VON KOENIGSWALD, 1939.) RECONSTRUCTED BY PROFESSOR F. WEIDENREICH.

in north China, I am inclined to regard these early pebble and flake industries as manifestations of a primitive intelligence decidedly less developed than that recorded by the Abbevillian and Acheulian tradition, in Europe and East Africa.

Already during the Second Interpluvial, or Interglacial, these early paleolithic cultures differentiated into an eastern and a western group. The latter was the hand-axe tradition which may not have necessarily been carried to India from East Africa or Europe, but quite possibly it developed in India independently from Africa. The hand-axes from Madras, for instance, have little in common with either the Abbevillian of France or the hand-axes found in Java. Though equally old, they may well have been made by people who had developed their own technique. We need not assume big migrations whenever we notice similarities of techniques for, after all, Early Man had only a very limited choice of stone flaking at his disposal. The fact that this western-tool complex in India was mixed with the eastern pebble-chopper culture is indicative of early differentiations, probably of a racial type. In this eastern realm crude pebble choppers take the place of the "bi-face" and dominate (with the flake-chopper and cleaver) the eastern technique. East of the Brahmaputra no real hand-axes or Acheulian traditions have been found. In Java also (though hand-axes are numerous) none of the typical bi-faces, or cleavers, occurs which characterizes Central and northwestern India. Between these regions there are funda-

mental differences in tool technique as far as the Paleolithic is concerned. We suggest that these variations are rooted in racial or phylogenetic differences. When it comes to detecting Mousterian or even later Paleolithic cultures, such as abound in the Upper Pleistocene formations of Asia Minor, East Africa and Europe, we see no equivalents in southern or Far Eastern Asia. The "loess cultures" of north China are typologically different from those found under the Würmian loess of central Europe. They belong in a class by themselves and seem to be rooted in the eastern pebble- and flake-tradition rather than in any Western culture.

Little understood as such typologic differences are, yet they become significant in the light of our stratigraphic scheme. For the first time their contemporaneous appearance is revealed, and with it the outlines of cultural and racial boundaries begin to emerge, even though faintly, from the dimness of those very remote ages. With this knowledge comes the demand for a new classification of the Asiatic Stone-Age tools. Heretofore they have been labelled with European terms, a procedure which needs to be changed in the light of this discussion.

The stratigraphic range of the human fossils found so far in Asia has been indicated in the figure. From it may be seen that the *Pithecanthropus* race was the earliest, having had a range from very early Pleistocene times (600,000 years ago) to the Second Pluvial and possibly Second Interpluvial. I may add that the great antiquity of this type is not inferred solely from the more primitive anatomy of the skull as compared to that of *Sinanthropus*, but also from the Early Pleistocene Age of the fossil infant from Modjokerto in eastern Java which F. Weidenreich considers to have belonged to an immature *Pithecanthropus*. The Peking Man race in North China appeared in the Second Pluvial and may have lasted into the long Second Interpluvial. Neanderthal Man of Java (Solo Man) is Upper Pleistocene, but judging from the stratigraphic range of worked flints, he may well have dated back to the close of the Second Interpluvial, as he actually did in central Europe (*Homo steinheimensis*). The fossil *Homo sapiens* is represented by Wadjak Man in Java and by the Upper Choukoutien cave types in China, as described by F. Weidenreich.

Such a chronologic sequence indicates that human evolution proceeded in Asia rather independently of climate, though future studies may prove that the major climatic changes brought about certain optima of life conditions. Such a period may have been the Second Pluvial (450,000 years ago). At that time the wide steppes of eastern and southeastern Asia must have changed to forests and the ocean level must have dropped due to wide-spread locking up of water through glaciation. This lowering must have formed a landbridge between Java and the mainland which permitted mammals to migrate freely from China into the Sunda region. This theory explains the appearance of a Middle Pleistocene "Sino-Malayan" fauna in Java at the time when *Pithecanthropus* lived on the banks of the Solo River. The shifting of vegetation belts and of coastal lands in southeastern Asia may have guided the early migrations of Man, and for this reason it would seem worth while to consider the soil-geological and paleobotanical approach in any future studies on human origins in Asia.

A PROPOSED GREAT PLAINS NATIONAL MONUMENT

By VICTOR H. CAHALANE[1]

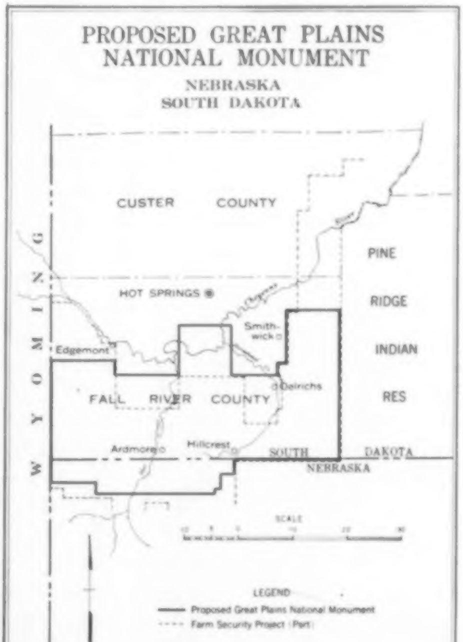
CHIEF, SECTION ON NATIONAL PARK WILDLIFE, DIVISION OF WILDLIFE RESEARCH, BUREAU OF BIOLOGICAL SURVEY

PROGRESS of civilization with accompanying development is changing the face of nature. In the eastern United States there remains hardly a square mile of unmodified vegetation. Even the surface of the earth itself—the hills and valleys, the course of streams—in places has been changed, either directly by engineering or indirectly by erosion. Life dependent upon these habitats must change with them or become extinct. Except through written descriptions, man loses contact with historical phases of his environment and opportunities for scientific work on it.

In the following paper, I have drawn freely from writings and unpublished reports of Dr. V. E. Shelford and other members of the Ecological Society's Committee on Preservation of Natural Conditions. Certain information on the animal and plant life of the area has been taken from Petry and Visher's account in the "Naturalist's Guide to the Americas" (1926). The forecast of probable vegetative cycles under protection, described on pages 132 and 133, is adapted from an unpublished report by Dr. W. B. McDougall.

A system of national reservations has therefore been devised within which samples of original America, with their plants and animals, may be perpetuated. National parks preserve outstanding scenery; national monuments protect natural phenomena and historic sites and structures. A comprehensive system of national monuments should include samples of ecological plant associations and, with them, their characteristic animals. Surely the prairie is a highly important kind of environment, and a small portion is worthy of preservation. The National Park Service, therefore, aided by the National Research Council and by the Ecological Society of America, has been for a number of years considering possible areas in the short-grass prairie region. Recent field inspections have indicated that a typical one has been found.

An area suitable for designation as a Great Plains National Monument must meet a number of important specifications if it is to serve its purpose. It must for several reasons be of large size. From



OUTLINE MAP OF PROPOSED MONUMENT

[1] Formerly chief, Wildlife Division, National Park Service.

Photo, 1938, by C. H. Wegemann, National Park Service

VALLEY OF A TRIBUTARY OF THE HAT CREEK DRAINAGE

EAST OF PROVO, SOUTH DAKOTA. THE YELLOW PINES IN THE MIDDLE DISTANCE ARE ON THE DAKOTA FORMATION WHERE IT COMES TO THE SURFACE. SOME DIVERSITY OF COVER AND SURFACE IS ESSENTIAL FOR THE LARGER MAMMALS OF THE GREAT PLAINS, AND THIS EXISTS IN THE NORTHERN PORTION OF THE PROPOSED GREAT PLAINS NATIONAL MONUMENT ALONG THE CHEYENNE RIVER.

the recreational point of view size is important, for the greatest inspirational value of the plains is to be gained from large areas free from traces of human developments. The scientist also demands large natural areas for some types of research. The preservation of truly natural conditions of vegetation requires that outside, man-caused factors be excluded. To prevent pollution of even a comparatively small central area by exotic plants that may spread and travel as seeds on the wind, a wide surrounding buffer zone under rigid control is a requirement. A long step toward permanent protection of numerous bird species consists in preservation of their normal habitat in some expansiveness. Also, if the larger members of the fauna of the Great Plains are to be restored under natural conditions a great acreage is necessary. Bison, antelope and elk need large amounts of forage, which in the short-grass type is not truly abundant. If the bison, particularly, is to be preserved as a wild species in the United States, it must be granted a large natural range free from the domesticating confinement of small fenced parks. From a consideration of all these points, it seems that a million-acre tract would be needed.

Size being a necessity, it is also evident that the shape of the area selected would be important. The most ideal one would be essentially isodiametric, for an elongated section of land would be more and more exposed to outside influences with any increase in the ratio between length of boundary and acreage.

Although not ideal in all respects, most practical requirements are fulfilled by an area of about three quarters of a million acres occupying southern Fall River County, extreme southwestern South Dakota, with a relatively small extension into adjacent Sioux County, Nebraska. Approximately 50 per cent. of the desirable lands are in federal or state ownership (notably land retirement

Photo, 1938, by C. H. Wegemann, National Park Service

LOOKING EAST FROM A POINT JUST NORTH OF ARDMORE, SOUTH DAKOTA

THE LOW HILLS OF THE PIERRE FORMATION, BY SPARSE COVER AND PRESENCE OF WEEDS, SHOW DISTINCT SIGNS OF DROUGHT AND ABUSE THROUGH OVER-GRAZING. THE LINE OF TREETOPS ACROSS THE MIDDLE DISTANCE IS ALONG A (DRY) WATERCOURSE OF THE HAT CREEK DRAINAGE.

purchases of the Farm Security Administration now under the control of the Soil Conservation Service), while over 8 per cent. more are county property.

The area selected for a Great Plains National Monument project is mostly of Cretaceous (Pierre shale) origin of a type uniform with the plain west of the Missouri River and exclusive of the Black Hills area. The tough gumbo soils of this semi-arid region are much eroded in some places, but the project has escaped severe cutting. The rounded hilltops vary in elevation from 100 to 300 feet above the valley bottoms, or coulees. Most of the streams are temporary in character, often going dry except in periods of frequent rain.

The climate of southwestern South Dakota is relatively arid, as the average yearly precipitation varies from 16 to 20 inches. A distinct rainy season starts about April 1 and ends early in October. During that time approximately 75 per cent. of the yearly precipitation occurs. Summer rains are more local in character than those in the spring and fall, and the rainy period coincides with the growing season. November, December, January and February are the driest months of the year. Winter temperatures average about 26° F. January is the coldest month of the year. Snowfall is usually light, except in March. The lowest temperature ever recorded in Fall River County is –42° F. at Oelrichs. Summer temperatures generally average around 65 degrees but exceed one hundred usually more than once a year. July and August are the hottest months. During periods of coldest weather, there is not much wind and the severity of the cold is somewhat mitigated by low humidity at the time.

The dry plains of the western part of the State of South Dakota, including the area under consideration, are covered by a short grass sod in which grama grass (*Boutelous gracilis*) and buffalo grass (*Buchloe dactyloides*) were originally dominant. Many xerophytic herbaceous plants as loco (*Oxytropis lambertii*),

Photo, 1938, by C. H. Wegemann, National Park Service

SOUTHEAST FROM ABOUT 6 MILES EAST OF ARDMORE, SOUTH DAKOTA

THE VEGETATION HAS BEEN NOTICEABLY THINNED BY OVER-GRAZING, DROUGHT AND ACCOMPANYING FACTORS, ALTHOUGH THE SOD HAS NOT BEEN DISTURBED. THIS SCENE IS NEAR THE CENTER OF THE GREAT PLAINS NATIONAL MONUMENT PROJECT.

Photo, 1938, by C. H. Wegemann, National Park Service

SOUTH FROM ABOUT 12 MILES EAST OF ARDMORE, SOUTH DAKOTA

THE MORE DROUGHT-RESISTANT AND UNPALATABLE PLANTS HAVE RESISTED STRESS AND HERE FORM ONE OF THE HEAVIEST COVERS IN THE AREA. THE MOST DISTANT RIDGE IS IN NEBRASKA.

Artemisia frigida and *Chrysopsis villosa* are mingled with the short grass sod and have become more important elements as range deterioration progressed. Small remnants of the short grass vegetation persist in the badlands.

Along the few stream courses, most of which cease to flow at least during the long hot summer, cottonwoods and willows are the most prominent floral elements. Elm and box elder, however, are not uncommon. Scattered red cedars are found on the upper reaches of the tributaries and in most situations a buffalo berry (*Lepargyrea argentea*) occurs.

The grassland is the home of the northern skunk and spotted skunk (*Spilogale*), the badger, prairie coyote, black-footed ferret, swift fox, black-tailed prairie dog, the pallid striped ground squirrel (*Citellus tridecem lineatus pallidus*), sage pocket gopher, pocket mice (*Perognathus* ssp.), kangaroo rat, white-tailed jack rabbit, Wyoming cottontail and the Osgood deer mouse. The gray wolf, bison and mule and probably white-tail deer formerly occurred there but are now extinct in the region. The Audubon bighorn, which once lived along the rivers and in "badlands" of any size, is now completely extinct. Pronghorn antelope were numerous in early times and may occur accidently as they are present west of the project in Wyoming and some distance to the south around Agate, Nebraska.

U. S. Department of Interior

SITE OF CAMP NEAR CHURCH BUTTES, WYOMING, IN 1870

NOTE CLEAR STREAM WITHIN ITS BANKS AND VALLEY BOTTOM COVERED WITH TALL GRASS, UNLIKE CONDITIONS TO-DAY. THE RANK GROWTH OF GRASSES SHOWN WAS PROBABLY WESTERN WHEAT-GRASS, PRAIRIE CORD GRASS AND SOME JUNCUS SPECIES.

Along the larger stream courses the list of mammals may be somewhat larger. Bats come to drink here and raccoons to catch crawfish. An occasional western fox squirrel is found in the groups of large cottonwoods and willows. The Cheyenne and White Rivers and many of their larger tributaries are known to contain Missouri River beaver (*Castor canadensis missouriensis*). Under present

Soil Conservation Service

SAME SITE AT CHURCH BUTTES, WYOMING, AT PRESENT TIME

THE VEGETATION IN THIS PHOTOGRAPH, 67 YEARS LATER THAN PRECEDING PICTURE, IS PREDOMINANTLY A SAGEBRUSH TYPE. THE MAIN SPECIES ARE BIG SAGE AND RABBIT BRUSH, WITH TRACES OF WESTERN WHEAT, PRAIRIE CORD, JUNCUS AND DROPSEED SCATTERED THROUGHOUT THE AREA.

conditions, it is fairly certain that no beaver occur within the boundaries of the proposed grasslands area.

Although this section of the plains is not a vitally important habitat for vanishing bird species, several rare or uncommon kinds use it during at least a portion of the year. The long-billed curlew, once common, is still found nesting there. Four were seen at Hillcrest on June 14, 1938, and several others the following day near Folsom, about 20 miles north of the northeastern corner of the proposed monument. The whooping crane was recorded by H. H. Sheldon on October 4, 10 and 16, 1915, on the Pine Ridge Indian Reservation. The writer also saw a flock passing very high over Sheep Mountain, at the western end of the Badlands, on October 13, 1935. Prairie sharptailed grouse were once common and would regain their former numbers with adequate protection and the return of normal vegetation. There are records of the greater prairie chicken from nearby areas (Badlands, Pine Ridge Indian Reservation). Water-loving birds are comparatively scarce, for their special environment is of course very limited, but four herons, five sandpipers, two geese and seven species of ducks have been noted in the project or within 25 miles of the boundaries. A few mallards and pintails are found on every permanent stream, even though small in size. Surface water is at a premium on the plains, especially in the southward migration, and ducks are surprisingly abundant in fall. Birds of prey are numerous in species and individuals. Eight kinds of hawks have been recorded in addition to the golden and bald eagles and the osprey.

The only permanent avian resident represented by many individuals is the desert horned lark, which in late summer and fall is very abundant. Great numbers are killed at this time by speeding automobiles. Probably these are almost entirely young of the year, for no dead

larks are to be found after the end of December, although survivors are still abundant on the roadsides. Longspurs of some species are found in all seasons, the chestnut-collared and McCown's longspurs nesting here abundantly and the Lapland longspur wintering. Two other members of the sparrow family, the lark bunting and the western vesper sparrow, are very numerous; the former is quite characteristic. Other prominent nesting birds are the Brewer blackbird, Sennett's nighthawk, upland plover and burrowing owl. The latter, unfortunately, is comparatively scarce, for extermination campaigns aimed against prairie dogs have indirectly affected the birds dependent on the burrows for dwelling and nesting places. Several kinds of birds nest in the groves of scattered trees along the streams, but often feed on the steppe far from their nests. Examples are: the ferruginous rough-legged, Swainson's and sparrow hawks. Cliff and barn swallows, nesting on cliffs or about buildings, are also seen often, as well as the bank and violet-green swallows. The total number of bird species is especially large, because the western Dakotas lie on the meeting-line of eastern and western avian faunas, where forms common to both mingle. A great increase in the number of individuals would almost certainly follow restoration of normal ground cover and the re-elevation of the water table to its natural level.

The most common snake is the plains bull-snake (*Pituophis sayi*), with the plains blue racer (*Coluber constrictor flaviventris*) next and the prairie rattlesnake (*Crotalus confluentus*) third in most places and seasons. The horned-lizard (*Phrynosoma*) is numerous in many localities. The common toad (*Bufo woodhousii*) is seen frequently. The Great Plains toad (*Bufo cognatus*) is characteristic but not abundant.

The area proposed for establishment

U. S. Bureau of Biological Survey

AUDUBON BIGHORNS ONCE LIVED IN THE BREAKS

THE LAST AUDUBON BIGHORNS OR BADLANDS MOUNTAIN SHEEP WERE EXTERMINATED FROM THEIR GREAT PLAINS HABITAT ABOUT 1918; CONSERVATION POLICIES ARRIVED TOO LATE TO SAVE THEM. THEIR SURVIVING RELATIVES OF THE ROCKY MOUNTAIN VARIETY WERE PHOTOGRAPHED ON THE NATIONAL BISON RANGE, MONTANA.

as a Great Plains National Monument has been much abused by overgrazing and to a small extent by plowing. Any plans for restoration to a normal condition must take this into account. While some erosion control work can probably be carried on in order to hasten rehabilitation of the land, time is the agent that will heal the scars most effectively.

The short grasses of the plains region may be considered as representing the climax type of vegetation for the region—in other words, the most mesic vegetation that the climate, especially the water supply factor, will support. The hillocks will probably be too dry for the climax vegetation, but these will be worn down until conditions suitable for the climax are attained. On the other hand, if there are shallow depressions too wet for the climax, they will gradually fill up until the same medium conditions are reached. When the climax vegetation has been established, it will persist indefinitely unless destroyed by one means or another, or a change occurs in the climate. When the climax vegetation is destroyed by any means, the resulting bare area will always be drier or wetter than it was when occupied by the climax vegetation. As a result there will be a natural succession of plant forms on the area until the medium conditions that will support the climax vegetation have returned.

When the short-grass plains climax vegetation is destroyed, the resulting bare area is moister than the areas occupied by the vegetation because an immense amount of water is lost through the plants. The first stage in the succession on such an area is an early weed stage, which occurs from one to three years after the area has been abandoned. The plants are principally smartweed (*Polygonum aviculare*), Russian thistle (*Salsola pestifer*), verbena (*Verbena bracteosa*), gum weed (*Grindelia squarrosa*), plaintain (*Plantago purshii*) and six-weeks fescue (*Festuca octoflora*).

National Park Service, by Frank Oberhansley

BISON AND ELK WERE ONCE PLAINS DWELLERS

BUT ECONOMIC DEMANDS EXTIRPATED THEM FROM AGRICULTURAL AND GRAZING LANDS ON THE AMERICAN PLAINS. EXCEPT FOR A HERD IN CANADA, BISON NOW PERSIST IN A TRULY WILD STATE ONLY IN THE WOODED MOUNTAINS OF THE YELLOWSTONE NATIONAL PARK.

U. S. Bureau of Biological Survey

BULL ELK IN VELVET

ELK OR WAPITI WERE ONCE RESIDENT IN BRUSHY CREEK-BOTTOMS THAT FURROW THE GREAT PLAINS.

During the second stage these weeds increase until they use all of the available surface water during the season. This stage lasts for two to five years and, before it ends, young plants of tumblegrass (*Schedonardus paniculatus*), *Gutierrezia sarothrae* and false mallow (*Malvastrum coccineum*) will be found.

In the third stage, lasting four to eight years, tumblegrass is dominant. This is a short-lived perennial grass and a surface feeder. It crowds out the annual weeds. Along with it will be found many plants of *Gutierrezia*, which is a deep-feeding perennial.

The fourth stage, lasting seven to fourteen years, consists largely of the deep-feeding *Gutierrezia*, together with some tumblegrass and occasional plants of buffalo grass (*Buchloe dactyloides*).

The fifth stage, 12 to 25 years, is dominated by buffalo grass, together with some plants of the earlier stages.

Finally, in the sixth stage, 25 to 50 years, buffalo grass and grama grasses (*Bouteloua*), long-lived, surface-feeding, short grasses, kill out the deep feeders by utilizing all available water before it penetrates to the deeper layers. Thus the typical short-grass vegetation is reestablished.

This succession may be modified by any number of local factors or by such climatic factors as wet and dry cycles. In general, however, it may be expected that it would take from 25 to 50 years to reestablish the typical short-grass vegetation in places where it has been destroyed.

This great area, if set aside for national monument purposes, would present peculiar problems in restoration, administration and protection. Keeping in mind the primary need for recuperation of the vegetation, provision must necessarily be made for the reintroduction of small numbers of the more conspicuous mammals now exterminated. Restoration of bison, elk and antelope presuppose the construction of a fence sufficient to prevent the animals from wandering to agricultural areas and such a project,

U. S. Bureau of Biological Survey

WATERFOWL FIND WATER SCARCE FOR NESTING

BUT PARENTS, LIKE THESE CANADA GEESE, REARED BROODS WHEREVER WATER WAS AVAILABLE.

involving approximately 200 miles of boundary, would be a large task. Fence construction on such a scale would be by no means out of reason, as barriers of much greater length have been completed in Australia as public or state projects. In a large area, however, it is probable that fencing would not be needed for some time if watch were maintained over the animals' movements. Periodical herding of a comparatively small number of bison or other grazing mammals should suffice to prevent straying beyond the exterior boundaries.

Restoration of that large carnivore, the wolf, would, however, be attended with more serious difficulties. Nothing of this nature could be attempted until a tight fence could be constructed around the project in order to prevent natural gravitation of wolves to regions where their presence would interfere with economic interests.

It is probable that in time an entirely new road system could be laid out to suit the distinctly different uses of the land. The type of construction would be simple, for only low-speed traffic, principally seeking views instead of mileage records, would need accommodation. The traditional type of road for the Great Plains is the rudimentary one or two wheel tracks. It is believed that this, probably oiled to allay dust, would be sufficient for most of the monument and quite in keeping with its purposes.

A large staff, at least for administrative and protection purposes, would never be needed. Protection of the "game" mammals and other wildlife would also be less troublesome than in forested country and poaching much more easily detected.

Because of the nature of the experiment there should be no development in the popular sense of the term. The only

Haynes, Inc., Yellowstone Park

THE ANTELOPE ONCE WERE PLENTIFUL

IN THE PLAINS REGION WHERE THEY FORMED AN INTEGRAL PART OF THE BIOLOGICAL COMMUNITY. A BUCK PHOTOGRAPHED IN YELLOWSTONE NATIONAL PARK WHERE A HERD OF 800 IS FLOURISHING.

U. S. Bureau of Biological Survey

THE PLAINS WHITE-TAIL DEER NEEDS BRUSHY VALLEYS

AND DISAPPEARED FROM THE PLAINS WHEREVER THESE WERE "CLEANED UP" OR SETTLED.

development permitted would be that necessary for the protection of the area and to accomplish the purposes for which it would be set aside.

It is believed that the reservation of an adequate sample of the Great Plains, under administration that would preserve *all* factors of the environment, can be justified on scientific, economic and recreational grounds. Grassland is one of the most important of all vegetational features. Shantz's "Plant Resources" in Encyclopedia Britannica, 1930, pages 858–860, estimates the division of the 52 million square miles of the earth's land area as follows: desert, 13 million square miles; forest, 17 million square miles; grassland, *22* million square miles.

Furthermore, Shantz and Zon (Atlas of American Agriculture, Natural Vegetation, 1924, page 3) have estimated that *38* per cent. of the original total area of the United States was grassland. Agricultural use has converted some of this to tillage, and misuse has further reduced the arable area. From the economic and scientific point of view, therefore, it is of enormous importance that the remaining grassland receive further study and proper treatment.

Approximately half of the world's total land area can never be cultivated, for much of the desert has no water, some areas of forest are too rocky, poorly drained or otherwise unsuitable, and vast acreages of grassland would be ruined by erosion if the sod cover were broken. It is important, therefore, to learn as much as practicable concerning use of these lands for other purposes.

We have no assurance that our present methods of handling our western plains are those that will result in maintaining an unimpaired resource. As a matter of fact, the severe test to which the prairies have been subjected during the recent cyclic drought would indicate otherwise. Various signs have pointed out that many

U. S. Bureau of Biological Survey

AN ALBINO BISON CALF

IS A RARITY THAT WAS REGARDED WITH RELIGIOUS AWE BY THE PLAINS INDIANS. NATIONAL BISON RANGE, MONTANA.

U. S. Department of Interior

MULE DEER WERE FOUND

ON THE GREAT PLAINS WHEREVER PATCHES OF WOODS AFFORDED SHELTER.

areas have been seriously damaged by unwise plowing or overgrazing and that a radical departure in methods of handling must be instituted. Otherwise, great tracts of grasslands will revert to semidesert that will require impossible lengths of time for rehabilitation. Possession of a large check area that will be allowed to remain in its natural condition would be a continuing standard against which it would be easy to establish divergence of similar grasslands under economic use. Adoption of new methods of use would be in order if agricultural or grazing areas showed indications of excessive damage. The presence of such a check area also would make it possible to apply new methods and desist from old ones before extensive damage made it obligatory to use costly means for rehabilitation.

The great cereal-growing and grazing areas of central North America were originally grassland, supporting a large animal community characterized by many of the best-known large mammals and birds and many rodents and small carnivores, as well as reptiles and invertebrates. Its original life has largely been destroyed without adequate study, from the standpoint of either pure or applied science. Results valuable to the general sciences of paleontology, geology, geography, botany and zoology, and especially to modern ecology could have and even now can be obtained. Fortunately, representatives of all the species of animals (except bighorn) are still available for research purposes.

A. A. Allen

SANDHILL CRANES

SIMILAR TO THIS FLORIDA CRANE, NESTED IN SLOUGHS. NOW THEY ARE UNCOMMON MIGRANTS OVER THE PLAINS AREA.

It is an ideal habitat type in which to study biotic interrelations, fluctuations in abundance of animals and other basic principles. There is need for checking the philosophical doctrines of biology by observations in nature. Very little work of this kind has been done and observations lack continuity. The various doctrines of biology, past and present, such as natural selection, sexual selection, emergent evolution, etc., doctrines concerned with the changes in abundance of animals, involving theories of immunity, disease, competition, sunspots and favorable and unfavorable weather or radiation conditions, biotic potential and environmental resistance, have never been checked by continuous observations in nature. Experimental work intended to throw light on these questions, especially those concerned with abundance, has not been guided by the relations of the animal in nature but rather by the dicta of physics and chemistry or even the operation limits of commercial apparatus.

Continuous quantitative and qualitative observations of organisms in nature in correlation with the surrounding physical conditions, especially their fluctuations, should in itself form a basis for important discoveries. Theories may also be developed. These may be experimentally tested when a suitable foundation

has been laid. The study of the complete biotic community should add much to our knowledge of interactions.

Grassland is an excellent field of scientific study for the following reasons:

1. It affords full visibility of most important animals and plants.
2. The life histories and life span of the dominant plants is about one-tenth that of forest trees, which greatly facilitates observation.
3. Although there is great ecological interest, much less research of this kind has been done here than in the forest.
4. There is a close relationship of these problems to agriculture.

Scientists have long been interested in the study of nature from the standpoint of plant and animal communities, the physiographical and competitive relations of their constituents, and similar matters. This field of knowledge has important bearings on various other scientific and philosophical questions.

The Great Plains have figured extensively in our history both in colonial times and during the period of westward expansion. Although the area proposed for establishment as a grasslands national monument is north of the old main travel route, the Oregon Trail, it is nevertheless typical of many of the high plains over which the colonists made their way. Much of the north and south travel from Forts Kearney and Niobrara in Nebraska to the Black Hills went through the area. The early stage route from the North Platte River through Buffalo Gap to Deadwood traversed this country crossing the Cheyenne River at a ford south of Buffalo Gap.

It is certain that there will be considerable public interest in a restoration of the prairie with its vegetation and fauna. It is not likely that the general public would want to stay in it for long periods of time. The landscape and its plant and animal communities are not sufficiently diversified to hold unspecialized interest.

U. S. Department of Interior

CANADA GOOSE

MANY CANADA GEESE NESTED IN THE PONDS OF THE GREAT PLAINS AND ALONG THE RIVERS.

Herds of the larger mammals, however, as well as the numerous species of prairie birds, would be certain to attract large numbers of the public and it is undeniable that the landscape has an appeal peculiar to itself. It makes a tremendous impression, similar to the effect created by unlimited ocean or other vast expanses. As Van Dyke says:

> How often have we wondered why the sailor loves the sea, why the Bedouin loves the sand! What is there but a strip of sky and another strip of sand or water? But there is a simplicity about large masses—simplicity in breadth, space and distance—that is inviting and ennobling. And there is something very restful about the horizontal line. Things that lie flat are at peace and the mind grows peaceful with them. Furthermore, the waste places of the earth, the barren deserts, the tracts forsaken of man and given over to loneliness, have a peculiar attraction of their own. The weird solitude, the great silence, the grim desolation, are the very things with which every desert wanderer eventually falls in love.[2]

[2] "The Desert," pp. 18–19.

FORTY YEARS OF SOLEDAD

By Dr. THOMAS BARBOUR and HELENE M. ROBINSON[1]

MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD UNIVERSITY

ZOOLOGISTS, as well as botanists, have visited Cuba in numbers to work at the Atkins Institution of the Arnold Arboretum at Soledad, Cienfuegos, Cuba. Composed of a biological laboratory, a dormitory and over 200 acres of cultivated land, the garden contains plant material from the whole tropical world. Close cooperation is being maintained with the biology department of Harvard University in this work.

The station has its origin in an experimental garden established in 1899 by Mr. Edwin F. Atkins on his sugar plantation in Soledad. Mr. Atkins left Boston as a young man to take charge of his father's business interests in Cienfuegos, now over 70 years ago. He acquired land from time to time and by the period of the Spanish American War had one of the most modern and progressively managed sugar estates on the island, an estate on which, to this day, the workers are not a floating population but a group of neighbors and loyal assistants, depending on the management for advice and help, generation after generation.

After the Cubans won their independence, Mr. Atkins became interested in the possibility of raising a better variety of sugar cane, as well as temperate zone vegetables and plants. He consulted Professor Goodale of Harvard. They, with Professor Oakes Ames, worked over the proposition and, in 1899, set aside eleven acres of land as an experimental garden. Mr. Robert M. Grey, an accomplished plantsman and horticulturist, went down to Soledad and, with Mr. Bohnhoff, laid out trial beds for vegetables and started experiments in hybridizing sugar cane to produce canes resistant to the diseases which beset most of the local varieties, and to contain a higher sugar content.

[1] Photographs not otherwise credited taken by David Sturrock.

It was here that the first potatoes were grown in Cuba. As a result of Mr. Grey's industry and tireless endeavor, it was found that many of the vegetables enjoyed in the temperate countries can be raised in the dry season on the island. As time passed other experiments were undertaken: grasses for richer pasture, and the importation and hybridization of fruit trees, ornamental trees and shrubs. No segregation of species or families was attempted, for the garden was small. However, as time went on and more land was needed, Mr. Atkins and, later, Mrs. Atkins and Mr. Claflin gave additional acreage, until now the garden comprises 221.63 acres. Dams have been built to form ponds and reservoirs, not only for the storage of water for use in dry seasons, but also to allow the cultivation of water plants. Here you will find, for instance, many species of lilies, lotus and papyrus and, along the banks, bamboos and other grasses.

The garden grew and flourished for a score of years until, eventually, Mr. and Mrs. Atkins decided that the establishment could be made more useful and of greater value to science if a biological laboratory were built so that botanists and zoologists could live and work, undisturbed, near the garden. In 1924 Harvard House was built, plans for which were drawn by Mr. C. A. Coolidge. It is a low, cool stucco building to the west, between the garden and the Central. Here is a laboratory well stocked with microscopes, glassware and equipment, a dining room for the scientists and a wide, shady porch. Mr. Sturrock and Mr. Walsingham live here.

In the summer of 1932 the Cuban Sugar Club was obliged to discontinue their organization at Central Baragua and offered to loan their collection, materials, records, equipment and furniture for use at Soledad, with the understand-

ing that if they reorganized within a period of five years this would be returned to them and, if they did not do so, it would become the property of Harvard University. This equipment and the collections have been of great value and usefulness. While every one regrets the discontinuance of the excellent work the Cuban Sugar Club was doing in basic research along various lines, it is a source of great satisfaction that they considered Soledad as the depository of their valuable possessions.

Mrs. Atkins, whose interest in the garden has continued during the entire period of its existence, provided the equipment to store conveniently a Cuban herbarium comprising material secured not only in the garden but from the whole Soledad region, including the Trinidad Mountains. Professor John G. Jack, of the Arnold Arboretum, made many collecting trips over a good part of the Province of Santa Clara and with the aid of numerous students a first-class local herbarium is kept at Harvard House, conveniently arranged for consultation. This material has been of great benefit to the many entomologists who have been interested in determining the food plants fed upon by the species which they were studying.

Last year a dormitory, Casa Catalina, was built. It is situated between Harvard House and the garden, overlooking the garden and with a delightful view of the Trinidad Hills beyond. There are two rooms with two beds each and a dormitory with eight beds. Two bathrooms, a storage room, which can eventually become a kitchen if desired, and a dressing room complete the interior of the building. Along the eastern side of the building is a wide porch. Chairs, stools and tables make it a pleasant and comfortable place to work and, since it stands on a slightly higher elevation than the surrounding territory, there is usually a cool, refreshing breeze.

In 1934, to make the administration of the garden less cumbersome, it was decided to join the Cuban establishment with the Arnold Arboretum in Jamaica Plain, renaming it the Atkins Institution of the Arnold Arboretum.

The Corporation of Harvard College

Photograph by J. H. Welsh

HARVARD HOUSE FROM THE EAST

REFLECTIONS OF GARDEN VEGETATION IN TWO PONDS

Above: A POND IN THE OLD GARDEN WHICH IS NOW BEING CONVERTED INTO A PALMETUM. *Below:* ONE OF THE NEWER PONDS SHOWING YOUNG PLANTINGS ALONG THE BANKS.

awards two fellowships a year to students of biology at Harvard who wish to study in the tropics. When possible, additional fellowships have been granted from the income of the Atkins Fund, but the expenses of the enlarged garden have increased so greatly that nowadays there are seldom funds enough for this purpose. However, one way or another, many students have been enabled to work at the station.

A lull in the activities of the laboratory came in 1931 when revolutionists became active in the vicinity and it was deemed inadvisable to send students from Cambridge. In this period, however, the regular work on the garden continued without interruption.

In 1935, Cuba, and especially Santa Clara Province, was visited by a terrific hurricane which destroyed many trees and ruined many others, as far as beauty and proportions were concerned. The younger trees and plants have come back remarkably well. In fact, a stranger visiting the garden now would not know that it had experienced a hurricane at all, but those who knew the place of old miss many landmarks.

When, a year or two later, Mr. Grey retired and Mr. David Sturrock went to take over his duties, he and Mr. Walsingham, the assistant superintendent, decided to divide the garden into sections, devoting each section, so far as possible, to a specific family of plants. This is slow work and not all the garden has been arranged as yet. For instance, the portion set aside for a nursery for newly received plants was a field of sugar-cane last year. The Ficus collection has not yet been segregated, though a large area is so marked on the map.

A few years ago cattle grazed in the southwestern part of the present garden. This area consists of limestone outcrops which are so broken and worn that the cattle made their way through it with difficulty. Until recently this was untouched, but Mr. Sturrock saw the possibility of using these wild, craggy places for succulents, and "Utah" and "Arizona" were started. Here there is to be found an enormous number of species of cactus and euphorbia. "Arizona" is laid out on the side of a hill at the top of which is built the facsimile of a porch of a native adobe hut, surrounded by colorful plants which are not only lovely to look at but attract many birds, butterflies and other insects. From this porch can be seen, in the distance, the Trinidad Hills. Nearer at hand, between "Arizona" and "Utah," lies the "Sebrucco," devoted to native trees and plants. Here trees and bushes have been left as they grew, the native orchids and airplants adorning them. Only the grasses and weeds have been cut away to make paths where one walks in deep shade along the banks of a little wild brook with ferns on every side. A brief climb brings one to a summer house deep in the woods, a wonderful place from which to watch the birds and other inhabitants of the shady forest.

Throughout the garden run grassy roads and paths, now few in number, but more of these are being made as the undergrowth is cleared away and new plantings set out. By means of these roads it is possible to reach the distant sections by automobile or on horseback, as well as on foot.

When new seeds are received, and they come from all over the world, they are handed to Emilio Pastor, who plants them in pots in the greenhouse, each pot carefully labeled and each package of seeds numbered and duly entered on cards, where a record is kept of the progress and final location of the plant in the garden. Duplicate sets of these cards are in the greenhouse and in Harvard House. As the plant grows it is passed along from the greenhouse to the shade house, then the nursery and, finally, to its particular section of the garden. Each transfer is entered on both sets of cards, and a moment in the office of the greenhouse or Harvard House will enable a worker to locate any desired species.

ABUNDANT GROWTH IN TWO SECTIONS OF THE GARDEN

Above: A CORNER OF THE CACTUS COLLECTION. *Below:* A GARDEN POND CHOKED WITH LOTUS. PALMS AND BAMBOOS ON BOTH SIDES.

In 1933 it was decided that the tropical greenhouses of the Harvard Botanical Garden in Cambridge had best be dismantled and the larger part of the material therein was moved to Cuba and planted out. Since that time the establishment at Soledad has constantly supplied laboratory material for the botanical department of the university.

Native birds abound at Soledad and migrants move through the garden in waves each spring and fall. Insects and mollusks swarm, and of the latter the variety is almost endless. The pools and streams are filled with native fish and turtles. Not far away are the mountains and seashore, and collecting trips to either locality may be arranged.

Many scientists, other than graduate students or officers from the biological department of Harvard, have visited the garden and have worked in the laboratory. Among the very welcome visitors have been Drs. James C. Needham and Liberty H. Bailey of Cornell.

Dr. Filippo Silvestrei, of Portici, Italy, has spent considerable time collecting there, and used the Berlese funnel for the first time in Cuba.

Most frequent visitors have been Dr. David Fairchild, of the United States Bureau of Plant Introduction, and Mr. Allison V. Armour, whose yacht, the *Utowana*, has been fitted for botanical exploration and has made possible the collection and transportation of many of the introductions in the garden.

Dr. Wilson Popenoe, of the United Fruit Company, has frequently been to Harvard House and, through his interest and the courtesies of the United Fruit Company, many additions to the Garden have been made possible.

CASA CATALINA, THE NEW DORMITORY

Dr. John G. Myers, who was for years at the Imperial College of Tropical Agriculture in Trinidad, went to the garden first while a student at the Bussey Institution at Harvard and, after going to Trinidad, has found it not only pleasant and convenient but profitable to make frequent trips for consultation with its officers and for research in connection with his work in the British West Indies.

Scientists in Cuba frequently stop at Soledad; sometimes for a day or two and often for longer visits. A number of these scientists have been recognized as collaborators by official appointment by

A STREAM IN THE SEBRUCCO
A BIT OF WILD FOREST INCLUDED IN THE GARDEN AND DEVOTED SOLELY TO THE PRESERVATION OF THE NATIVE FLORA AND FAUNA.

the Corporation of Harvard College. Their advice and cooperation with the officers of the garden have been of great benefit.

After Harvard House was built a guest book was started in which all workers were asked to register. In some instances this has been overlooked and the book is, therefore, not a complete record of the visitors to the garden. This book, the card indices and the labels on the plants bear witness to the many ways in which the garden is indebted to its benefactors. Each page tells of the hospitality of the residents of Central Soledad and the faithful services rendered by the house staff. The earliest entries testify to the interest and generosity of Mr. Atkins and his family, and those following show that this kindly feeling still continues.

Although this list is by no means complete there were, in the spring of this year, 125 workers listed, of whom 58 were botanists, 57 zoologists, 4 medical men and 6 visitors who assisted scientists. These workers represented 26 institutions in 8 countries. Naturally the largest number of workers came from Harvard. The United States and Cuba were most frequently represented. The garden is often visited by guests and tourists from Cienfuegos and vicinity, and it is considered one of the show places of the south coast of the country.

Heretofore it has been necessary to limit the number of workers at Harvard House because of the sparse accommodations, and preference has, naturally, been given to students and officers of Harvard University. Casa Catalina, with comfortable accommodations for at least twelve persons, now offers increased facilities and makes possible the use of the laboratory and garden by visitors from other institutions at any time of year. It is the hope of the officers of the Atkins Institution of the Arnold Arboretum that many such workers will avail themselves of this privilege.[2]

Perhaps the greatest contribution which the garden has made to science is the opportunity it offers to young scientists who, for the first time, are able to see the tropical flora and fauna in their natural state, to which they will have occasion to refer during their research and teaching. In the past, and in fact at the present time, many young teachers enter upon their careers with no first-hand knowledge of the tropics, and the fellowships which Harvard offers are eagerly sought for by graduate students each year. They return with enthusiastic reports of the work they have been able to do and the firm resolution to go back at the earliest possible opportunity. In fact, many have made return visits, and now it is hoped that more will take advantage of its facilities.

[2] Scientists wishing to work at Harvard House should make application to the custodian, Dr. Thomas Barbour, Museum of Comparative Zoology, Cambridge, Massachusetts. Inquiries regarding the garden and the laboratory should also be addressed to Dr. Barbour.

WISE INVESTMENT OF LEISURE

By Dr. EDWARD J. STIEGLITZ
GARRETT PARK, MARYLAND

LEISURE is something to *use*—or to *abuse*. Leisure denotes opportunity. It may be a priceless asset or a dangerous liability. Fleeting and transient, leisure eludes us if unprepared. Leisure once wasted or spent can never be regained. Conversely, leisure once wisely invested can not be lost; the profit becomes an integral part of the individual. Herein lies the difference between the wealth afforded by leisure and the wealth of material things, which must ever remain extraneous. Investing is often more uncertain and difficult than earning.

It is the application of leisure which determines, perhaps more than anything else, whether an individual be happy or unhappy and whether a community or a nation progress or retrogress. Work, no matter how depressingly routine or physically unpleasant, becomes justified by the major objectives: security and appeasement of hunger. Leisure has more subtle and variable objectives: the satisfaction of emotional luxuries. The physician views leisure as a therapeutic measure, potent in the amelioration of grief and dissatisfaction, but likewise fraught with menace if stupidly applied. The fact that a little does good never warrants the conclusions that more will necessarily do better. Like an active drug, leisure is a two-edged sword, and we must consider the dosage, toxicology, indications, limitations and methods of application before we may hope to obtain the maximum benefits. Furthermore, the application of leisure must be an individual matter; "one man's meat is another man's poison."

The wise investment of leisure requires intelligent thought. Formal academic education is not requisite, nor is great material wealth. The ability to think and the ability to do are not so limited. But the ability to think is amenable to stimulation and development. Such is the primary purpose of education, and the responsibility for inspirational guidance rests squarely upon scientists.

The problems of leisure are not limited to the individual. They intimately concern the welfare of the community, the state and the nation. It could be said that the most searching single criterion of good, bad or indifferent citizenship is what the citizen does with his leisure. Public consciousness has become increasingly aware of the hazards of idle urban youth misapplying leisure. Witness the growth of boys' clubs and private and public playgrounds—all prophylactic measures intended to reduce the incidence of those with enhanced criminal inclinations in the forthcoming generations. While heartily in accord with these objectives, one can not help but feel that they do not go far enough. Inspiration toward sportmanship and in the techniques of cooperative living lags far behind the unnecessarily over-emphasized encouragement of intense competition. The will-to-win, if over-zealous, leads but to defeat. Certain national organizations, such as the Boy Scouts and the 4H Clubs among rural youth, are vastly more constructive in that they foster definitely creative activity.

Superabundance of leisure or the abuse thereof has marked and initiated the decadence of cultures throughout history. Mankind is essentially a lazy animal and unless prodded by some urgent necessity is prone to revert to spending his existence in search of mere

physical pleasure. Peoples become soft when an excess of leisure leads to indolence. The fall of ancient Rome, the cultural absorption of the Manchus in China and the decline of the early Egyptian civilization all serve to illustrate this. Such decadence threatens America to-day. The threat is insidious and deceitful in that it is so thoroughly sugar-coated with pleasures. Nevertheless, the threat is very real, for the sum total of leisure is increasing rapidly and nowhere is this increase so rapid and significant as here in the United States. With leisure and privilege constantly increasing as a result of technological advances, changed social trends and the luxurious comforts of modern civilization, there has accumulated a tremendous surplus of time, energy and capabilities which we, as a nation, must learn to use if we may hope to avoid the pitfalls of ineffectuality. The physical conquest of the land is largely accomplished; the intellectual conquest of human capabilities is just beginning.

Many factors contribute to the increase in leisure available. The correlation of cause and effect is sometimes obvious, sometimes obscure when leisure appears as a secondary by-product. There is great variation in the proportionate role played by the various factors in increasing the leisure of different individuals. Some of the causative influences warrant mention. Mechanical aids to living, tremendously enhanced speed of transportation and communication and an abundance of food, fuel and clothing have reduced to a small residual minimum the time required for the routine mechanics of living. Where our forefathers split wood, made candles or cleaned lamps, took days instead of hours to travel, we "save" this time and let a thermostatically controlled automatic furnace warm us and cheap power and light transport us. We have this time—but do we really "save" it? No—it is largely wasted.

Leisure is no longer limited to the well-to-do. Unemployment, the shortened working week and shortened working day all contribute to the increasing national leisure. It is no longer the poor who support the rich, for modern "isms" require the rich to support the ineffective poor. Idleness is supported by taxing the workers. By decree or by legislation, enkindled by the force of numbers rather than intelligence, the fit and useful are made to enhance the survival of the unfit. Such transgression of the natural laws of biologic progression can lead but to recession of the race of man. The politically motivated vicious emotional appeal to the herds of unemployed voters is through the cry of "underprivilege," ignoring the obvious truth that they, *en masse,* are in fact overprivileged!

Leisure must be earned to be appreciated. It must be appreciated to be used wisely. The stupid, vicious or wasteful expenditure of leisure may do immeasurable harm to the individual and to the state. Leisure is a dangerous force if uncontrolled. No rational mind would advise giving a child fire for a toy. Yet, by sophistry and eloquence "the more abundant life" is to be made available to the backwoods hill-billy and cheap electric power is to bring luxury to those too lazy to catch their own fleas. There is already an excess of leisure there. Concrete dams and electric power will not inspire thought in such indolent beneficiaries. Gray stone can never replace "gray matter."

The continued increase in longevity which has been so notable in the past fifty years is a less conspicuous, though very significant, factor in augmenting leisure. In 1900 the life expectancy at birth was but 48 years, in 1920, 54 years, and for 1940 it is estimated that it will be 65 years. Both the total and proportionate number of elderly people in the country have increased tremendously, and this shift in population age is con-

tinuing. In 1900 but 13.7 per cent. of the population were over 45, whereas to-day 20.2 per cent. have reached that approximate middle point of life. The percentage of those past 65 has risen from 4.1 per cent. in 1900 to 6.3 per cent. to-day. The consequences of this fundamental shift are legion and far-reaching. Urgent and unanswered problems arise in sociologic, economic, medical and psychiatric fields. Geriatrics in its broad sense is no longer largely of academic interest; it clamors for practical attention.

With aging come more leisure and new problems. The questions involved in the investment of leisure vary greatly with age. In childhood and early youth, leisure is normally employed in the release of surplus physical energy. Sports and games consume this excess effectively and simultaneously contribute to the development of vigorous bodies, quick wits and cooperation with playmates. After adolescence the utilization of leisure involves more complex interests; sex introduces music and literature in a new light, ambitions become more urgent, and curiosity often crystalizes. Dancing and reading compete with sports for leisure time. During the fruitful years of full maturity, leisure is most usually greatly limited. Here the concerns of everyday life, the necessity to earn a livelihood, the mating urge, the consequent responsibilities of rearing a family and the intensely competitive struggles for success leave but little time. What there is available is usually employed to further some one or more of these primary drives: golf "for business reasons," bridge to assist in the social "ascent," watching sports for physical rest and pure relaxation.

With advancing years and the inevitable slowing of the pace, the problems of leisure come forth more and more into consciousness. Now, for the first time, the individual may realize the value of leisure and laments the wasted opportunities of the past. More frequently, however, the value of leisure remains wholly unappreciated, and the futile waste goes on. Perhaps there is a gradual change in the activities, but the character of "spending" is unaltered. Physical limitations begin to have their effect, although this is rarely admitted. The urge for physical activity diminishes.

After the peak of activity around forty, many people gradually become aware of an ill-defined uneasiness and vague sense of frustration. They wonder occasionally at the time they've squandered and may be perturbed by the thought that their time is, after all, limited. What has all their work led to? Ambition, once an intense driving force, is prone to become vicarious: hopes that the children will accomplish all that they, the parents, have left undone. The one generation "passes the buck" to the next; unable to fulfil their own ambitions they expect their sons and daughters to do infinitely better. Frequently far more is expected of the next generation than its capabilities warrant. Too much pushing may induce unjustified and precarious inferiority conflicts in the younger folks. Boredom, born of the sense of uselessness and frustration, begins its insidious undermining of morale and enthusiasm. These profound and significant emotional reactions appear so gradually and silently that they are rarely recognized. People are conscious only of vague dissatisfaction, for mankind is usually too afraid of intellectual or emotional nakedness to expose the reasons by honest thought. Innumerable rationalizations, involving "hard luck," "bad times" or "no opportunity," are created to gloss over individual shortcomings. Rare indeed is the honest and courageous individual who will admit to himself that his shortcomings are his own fault!

This uneasiness and sense of defeat

usually come earlier and more abruptly to women than to men. From 40 to 60 most men are at the peak of productivity in their chosen careers. By happy delusions of inflated importance, men avoid the necessity of thinking; they are "too busy." Women, on the other hand, are far more prone to introspection, even though it may not *always* be honest. For the majority of women the great increment of leisure in middle or early later life comes on quite abruptly. Usually sometime between 40 and 50 they are suddenly confronted with the realization that the children have "grown up" and are busy with their own lives, that with economic independence the household requires but a minimum of labor or supervision so that they have an excess of time on their hands. Mixed with a depressing realization of their relative uselessness, there is always dangerous boredom. The efforts to escape take many forms. These usually reflect the previous background, and are largely determined by the individual sense of values. Women do not fritter their time away in "uplifting causes" because they *want* to, but do so in desperate and frantic attempts to escape boredom and the consciousness of their own littleness. They are not happy. The great tragedy lies not in the fact of their unhappiness but in the fact that it is so unnecessary.

Unfortunately, this all too frequent period of dissatisfaction from maladjusted use of leisure commonly coincides with the feminine climacteric and menopause. As a result of lack of absorbing occupations the minor discomforts and symptoms become grossly exaggerated, and ill health becomes the *modus operandi* of obtaining the longed-for attention and inflation of the ego. Admittedly the feminine climacteric is a period of some turmoil, but the great bulk of "complaints" have little or no true organic foundation and proper investment of leisure is often more effective therapy than endless "gland treatments."

With increasing age the chronic degenerative diseases appear more and more frequently. Thus in men and women alike there are many whose leisure is rather abruptly increased by partial invalidism. Not actually ill, but subject to restraint by their physical limitations are hundreds of thousands of middle-aged and elderly persons. Their enforced leisure can be a precious gift to swell the fullness of their lives or it may be a sore trial. The observing physician soon realizes that after middle life there is more actual unhappiness and discontent among invalids and handicapped persons because of failure to know how to use their leisure than because of any physical discomfort or distress. The majority are totally unprepared and helpless; existence often becomes a pathetic attempt to "kill time." The weaker personalities react to restrictions by hypochrondriac depression or neurasthenic emphasis of every minor symptom. Those who enjoy ill health are the daily curse of their families, friends and physicians. Stronger, more virile personalities bitterly resent their physical limitations and chafe and fret to their own detriment over the necessary restraints. It has been said that to prescribe retirement to the active, ambitious worker is tantamount to signing his death certificate within the year. This is often sadly true, because so few are prepared to live beyond the limits of middle age. The "one track mind" with a single interest is prone to crippling traffic tieups when some illness blocks that single activity. Multiple tracks permit re-routing of traffic; accessory interests allow the zest for living to withstand many accidents.

Increasing longevity makes the practical problem of how to enjoy life full of leisure, though limited by age or illness, a very common one. The years of harvest, when the fruits of preparation and of labor should be gathered, come earlier

to some than to others. They may arrive silently and so gradually that their coming is almost imperceptible, or abruptly and dramatically as a result of sudden illness or accident. Senescence is insidious, but inevitable with long life. The urgent problems arise with those whose enforced leisure is a sudden acquisition. In either type of instance the vexing problems arise only as a result of unpreparedness. Anticipation and foresight eliminate the common difficulties. Foresight requires no specialist's training, but only intelligence.

Education, which is preparation, has not kept pace with the changing social order and has made no provisions for the significant increases in longevity and leisure. Forty years ago, when the average life expectancy at birth was but 48 years and leisure was rare and limited to the wealthy, it sufficed that education prepare the boy or girl for the competition of adult life. In the intervening twoscore years, little has been added to this objective. The increasing complexities of civilization and the tremendous forward strides of the physical and biological sciences have increased the fund of technical knowledge necessary for the professions, and advanced university education has stressed the importance of creative thinking in research. But neither parents nor teachers have taken cognizance of the necessity of preparation for old age. It has been assumed with complacent smugness that the adult would learn how to grow old gracefully and happily without training or aid. Unfortunately, the majority do not learn this spontaneously. The time has come when educators have need to reconsider their curricula. Preparation must ever precede accomplishment.

For the wise investment of leisure only four requisites are necessary. Preparation, thought, and appreciation or enthusiasm, have already been mentioned. Material wealth is not needed; the riches of leisure are available to all willing to make the effort to grasp them. The fourth requisite is honesty: honesty in self-evaluation. Fair self-appraisal of capabilities and limitations is difficult. Being subjective it involves conflict between instinct and reason; instinct prescribes inflation of the ego, reason forces us to recognize our limitations. The eonian antiquity of these struggles testifies to their intrinsic basis. Honesty in evaluating objectives or values is equally important.

Those objectives most highly valued give insight into character. Other factors such as capability and opportunity being equal, it is the sense of values which determine the direction of activity and often the intensity thereof. By a man's desires shall you know him. All mankind is motivated by the simple and fundamental objectives of safety, comfort and the normal biologic sexual and physical urges. But the "emotional luxuries," or secondary objectives, vary greatly. It is these which demark man from most other mammalian species. Bread alone does not suffice; such existence is barren. In some, the sense of values places the desire to be well thought of in the primary position. These become the snobs, the sanctimonious and exhibitionists who employ leisure in vain attempts at ego inflation. Others value as priceless the wielding of power. These either degenerate into politicians, idolizers of money, self-appointed guardians of others morals or frank sadists. A finer, rarer few value the sense of progress above all else: the yearning to leave behind them something which adds to the knowledge, spirit or strength of mankind. Among these are the poets, scientists, explorers, artists and true tillers of the soil. Their dreams are always colored by curiosity; their hunger for truth is insatiable. Their satisfactions are two-fold: personal sense of progress and the warmth of having served and earned.

These hungers and varying valuations

thus largely determine both vocation and avocation. These latter in turn effect the individual usefulness and value to humanity. Greater thought and attention to the development of finer values in youth can react only to the benefit of mankind. It must not be forgotten that example still remains the most effective teacher.

Health is relative. Few indeed are the individuals in any walk of life who are completely and unreservedly "normal." Many are those who assume complete health because of the absence of subjective distress. But negative evidence is never proof. There are many disorders which advance silently until sudden unheralded symptoms betoken irreparable tragedy. Those disorders that "hurt early" are taken care of; those that do not cause distress are usually sadly neglected when most could be accomplished. Too many people take seriously the facetious suggestions of Mark Twain: "It is never too late to mend. There is no hurry."

Modern living, and especially urban existence, is extremely artificial. Abnormally sedentary, confining and asymmetric, the routines of existence frequently do not require enough physical exertion to keep the body in good condition. Living tissue must be used to maintain its full vigor. The complexities of the modern social structure, the noise, conflicts and wearing responsibilities of civilization abuse the nervous mechanisms; fatigue is accumulative.

Leisure affords opportunity for constructive physical exercise, beneficial to the skeletal and muscular structures directly and to the nervous system indirectly through mental relaxation and sounder, more refreshing sleep. But this does *not* mean that the physically soft executive or clerk should rush from the thraldom of the desk into tennis or violent handball at the "gym." To do such would be dangerous and absurd. There are many kinds of fitness in human beings, and muscular fitness is but one of them. There is no more need for the white collar worker to be a giant of muscular strength, the big muscle men of the "Health Clubs" notwithstanding, than for a small passenger automobile to be powered with a motor built for a ten-ton truck. There is a happy and sane middle course. *Exercise must be appropriate to the individual.* This is particularly essential in the later years of life or in the presence of some defect of health.

Exercise should be fun. It should yield mental relaxation. The same muscular activity and stimulus may come from pleasant outdoor sport or from monotonous calisthenics. The ritual of early morning setting-up exercises is usually a ludicrous performance: they are either soon discarded as the newness of good resolutions wears off or become a tiresome chore conducted without enthusiasm or pleasure and yielding a minimum of benefit.

Sports are highly desirable activities, especially for those whose responsibilities are continuous and heavy. With characteristic perversity, however, it is these tired, serious and responsible people who are prone to shun sports as a "waste of time." Properly applied rest is conservation of energy for greater usefulness. Human physical and nervous energy and reserve are like a bank balance: with withdrawal in excess of deposits the balance invariably goes down. Relaxation, sleep and food are deposits; work and worry are withdrawals. The human mechanism has extraordinary credit facilities in physiologic reserves. We may borrow from ourselves by "running on our nerve" or relying on stimulants and mental whips and spurs, but *such overdrafts must always be repaid.* Whipping a tired horse may make him go faster, but in the end he is that much more exhausted.

To be sure, there are occasions when emergencies warrant the use of these credits, but it must never be forgotten that sooner or later these debts to the body are "called." There is no escape or short cut. Inflationary cancellation is not permitted by the laws of nature. Neither legislation nor wishful thinking by executive proclamation can alter these laws. It is infinitely harder to re-establish credit once it is destroyed than it is to maintain it. The physician sees many of these physical bankruptcies, and one and all beg helplessly for rehabilitation—too late.

Games, sports or athletic activities are to be included among the many sources of rest or "depositing" made available through leisure. They can afford mental relaxation as well as physical exercise. What sports are appropriate after the fourth decade and why? Is it necessary to limit play-time activities to "old man" games? To answer the second query first: No! It is not so much a problem of *what* is done as *how* it is carried out. Even the patient with severe heart disease can climb stairs—if he does it slowly. I know a physician of 77 who still "plays" tennis and a financier who hired an extra caddy to help push him up the hills on the golf course. Both these men, and many others, continued their favorite sports for many years beyond the usual rocking-chair age because they recognized their limitations and acted accordingly. Such honesty in self-appraisal is, unfortunately, exceptional.

The capacity to tolerate violent physical effort without detriment definitely depreciates with advancing age. This depreciation starts in childhood but is occult until the later years of life, when objective evidence often becomes staggeringly convincing. Therefore, those sports or games where the player's activity depends directly upon that of his adversary are best avoided. This includes such games as tennis, handball, badminton and the like. They offer tremendous temptations to overdo. Being intensely and directly competitive they permit of relatively little nervous relaxation. Daily work is competitive enough. Golf, archery, bowling and the like are less directly competitive and therefore less objectionable. But wisest of all are wholly non-competitive activities such as swimming, horseback riding, walking, gardening, fishing and sailing. These are wondrously relaxing to the harried mind. Mental efficiency distinctly increases as a result of such rest. No one can worry about the "market" or sickness while astride a spirited horse or with a fighting fish on the line! These sports are independent of any opponent, which is a great advantage. With passing years, it becomes increasingly difficult to find appropriate opponents whose leisure time, inclinations and skill coincide. The greatest advantage of this group of athletic activities, however, arises from the fact that the exertions involved are flexible and therefore adjustable to the individual. They may be indulged in strenuously or leisurely and lazily. Day by day the capacity for exertion may vary. The ability to vary the dose of exertion to fit the changing capacity of the individual greatly enhances the therapeutic value of such sports. All can be profitably indulged in until senility really equals infirmity.

There are obvious limits to the benefits of exercise. The amount required for health varies greatly with individuals. Some bodies need far more than the usual sedentary occupations afford, but others thrive upon a minimum. Therefore, no hard and fast rules or generalized suggestions are justified: the specific problems of each individual must be considered separately. It is important, however, to avoid excesses in either direction. Physical indolence of fifty weeks is no sort of preparation for

two weeks of violent and excessive exertion in vacation time. The habit of attempting to concentrate all outdoor and athletic activity into short holiday periods invites disaster. Far better is a little often than much all at once! Habitual and non-seasonal exercising is preferable to purely seasonal activity.

There has arisen a curious tendency to take our sports or exercise vicariously. The huge stadia of the colleges, the immense grandstands for professional baseball fields, the increasing popularity of ice-hockey all bear witness to the commercialism which feeds upon and fosters this tendency. Professional athletes receive compensation comparable with those of real artists of the stage and ballet. Apparently the popular appeal of such sport spectacles is based upon purely vicarious thrills—the thrill of combat without risk. Like lurid adventures and exciting pioneering through the pages of a book!

From whence sprang this habit of taking our exercise sitting down and watching others perform? It is not hard to find the origin. For several generations many of our schools and colleges have sold local loyalty and tickets to the games, and thrown in some so-called education as a premium. Football brings in money. These games are contests, not of wits, but of brawn between semi-professional athletes who no more represent the university than does the janitor corps. Presumably a collegiate or university education is intended to prepare the students so that they might get the most out of their lives and contribute more to the commonwealth. Those students who obtain such educational values do so in spite of athletics. To be compatible with common sense and the true objectives of education, collegiate or school athletic training *should develop skill in those sports which the students can enjoy after graduation.* To how many does an "All American" medal bring health and happiness in later years? The chant of "teaching teamwork and cooperation" is worn threadbare. Sportsmanship is a mental not a physical quality. Physical cooperation is hardly necessary for the college graduate unless he be preparing for a career in the WPA. And even then, he must lean upon his shovel alone.

The same general criticisms are equally applicable to high schools and "preparatory" schools. A few students are encouraged to become highly skilled in sports which will be of no possible good to them in later years. Instead of football, baseball, track and basketball being the "major" school sports, instruction in golf, tennis, riding, swimming and the like would be infinitely more profitable to the student body as a whole. The violent competitive games have a high expectation of injury and are known to harm the youthful growing heart. The profit of sports which can be indulged in for many years would be both physical and mental. The habits engendered in youth remain. The residuum of enjoying sport vicariously is hardly desirable. It nurtures an unfortunate trend toward passive amusement.

There are innumerable people who require to be amused during every leisure moment. Bored and unhappy, apparently they are actually incapable of diverting themselves alone. This is a sad commentary upon their abilities, originality and intellects. These people are the habitués of the movie theaters, night clubs and bleacher seats; they make advertising pay by listening to the banalities and quackery of radio, and fill the rolls of lodges and clubs. Gregarious to an extreme, they must depend upon others to supply all ideas and yet would be the first to deny this if taxed. Amusement is something wholly passive to them. The intellectual atrophy that

comes from disuse makes them strangely gullible and highly non-critical. They may make ideal citizens in a totalitarian régime, but are hardly competent to guide the destiny of a democratic nation. Yet they have this responsibility.

The passive intellectual indolence may be extremely asymmetric. There are many instances of conspicuously so-called successful men totally unable to divert themselves when some illness or accident prevents continuance of their usual occupation. When deprived of the one and only outlet for their energies, these unfortunates are acutely miserable with intense boredom. Their misery is rarely self-contained, for the instinctive gregariousness of this type compels them to share their discontent with all those about them. Much domestic friction arises from boredom.

An illustrative case comes to mind! A young woman, of the type which requires exogenous amusement, lost her position as typist during "the depression." Before many months she was in the physician's office with a long series of vague complaints for which no organic bases could be discovered. She remained well nourished and physically comfortable, living with her parents. But upon specific inquiry, she admitted frankly that she was unbearably bored and dreaded each morning as the forerunner of another hopelessly tiresome day. She complained of being friendless. Her ego sought escape from what was to her an intolerable situation by the solace of ill health. By deliberately and bluntly informing her of this conclusion, explaining why and making specific recommendations for the investment of her superabundant leisure, she was jolted out of this dangerous rut. She was told: "If even you can find nothing interesting in your own company, you must be tiresome indeed. People without friends are those who have nothing to offer in the way of interest. How can you expect others to find you interesting if you bore even yourself? Study and learn to make yourself interesting!" Three months later she was a markedly changed woman. Previously sullen, disgruntled and resentful, she had become vivacious and lived with a zest her parents had never known. She reported her engagement to be married!

There are many lives lived happily and usefully because leisure is wisely invested. In most instances such happy lives are not fortuitous; they are predetermined by preparation in youth. Usually such preparation is undeliberate and unconscious. Probably the most potent forces are those of the home environment and the example of the older generation. In households where the perennial question is, "What'll we do to-night?" or "Who is coming for bridge?" it is almost inevitable that the children will fail to develop initiative and become members of the great herd demanding amusement without effort. On the other hand, where the parents are sincerely interested in creative activity in their investment of leisure, the next generation can not help but develop active mental habits and thereby become far better and more constructive citizens.

It is in creating something that we obtain our greatest satisfaction and happiness. The antiquity of this urge or driving force in the ascent of man demonstrates the depth of its rooting. It probably arose contemporaneously with the earliest beginnings of curiosity. Curiosity, according to the splendid philosophies of Clarence Day, is the basic driving force which led mankind to the position of the dominant species. The satisfaction of curiosity resulted in the creation of tools. The desire to *use* these tools (both physical and intellectual) merges imperceptibly with the urge to create. The cave paintings of the stone age were hardly utilitarian and probably constitute the earliest evidence of

leisure activity. *Recreation* is, after all, derived from and linked to *creation*.

The urge or instinct to create comes early to the child of man. It is thus a basic desire, for biology has repeatedly demonstrated the validity of the dictum that ontogeny recapitulates phylogeny.

It is relatively immaterial just what is created. The choice is intimately individual and depends upon tastes, values, abilities, limitations and opportunities. But the satisfaction of sincere creative effort knows no limitations. It is not the acquisition of the article created which results in satisfaction, but the fact that it was self-made. For example, give a boy a hammer, some boards, nails and a saw and he will make a box which will yield far more joy than any fine piece of factory-made cabinet work, even though it fall apart before very long. His second box will be better, and therein lies his joy of feeling progress. Why do people knit? Not because the sweaters, socks or articles created are cheaper or better than those which they might buy, but because of the satisfaction of having made them themselves. The value of such investment of leisure is three fold: such activities contribute to physical health, intellectual growth and emotional happiness.

Creative activity in its broadest sense is unlimited in scope and potentialities. Its intimate relation to curiosity is fundamental. The satisfaction of curiosity results in the creation of new ideas and in the acquisition of new facts. It is perhaps redundant and unnecessary to note these relations, for study and science are inseparable and the prime motivation of the scientist is curiosity. The mentally indolent requiring passive amusement can never appreciate the intense and lasting satisfaction of discovery, of having added a bit to the vast sum total of knowledge. Research is creative whether it be conducted in the laboratory, observatory, library or the seas and mountains.

Thus it is that we can say that the wisest investment of leisure lies in creative activities. There are many who recognize the value of hobbies but fail to make this fundamental distinction between creative and non-creative hobbies. The satisfactions of the one are lasting and accumulative; the pleasures of the others are transient. There is an immense fund of pride in knowing or doing *any one thing well!* In discussing these concepts with many patients one often hears the bewildered complaint, "But what can I do? I have no talent!" This is rarely literally true, for creative activities possible to-day are truly innumerable. There is no more fundamentally creative activity than rearing children (creating character) and making a home. There are innumerable women who merely need to have the distinctions between a home and a residence made clear to them and they are happily busy. Too many American domiciles are "a garage with a bedroom and bath attached"! The most encouraging sign indicating that American culture can and will survive the present dangerous superabundance of leisure is the spread of the home work-shop and the many gadget magazines.

It is impossible to enumerate here all the possible creative hobbies. Creating music (in any form and with any instrument), drawing, painting, modeling, writing all cost next to nothing. Yet the dividends of satisfaction are tremendous. The author is frankly getting more pleasure from writing this than the reader is from reading it, for reading, unless part of a planned study program, is hardly a creative hobby. Wood-working, photography and gardening are slightly more expensive hobbies, for they use up supplies. But they need never be prohibitively expensive, for modesty in projects does not chill the keen pleasure of well-done work. Breeding and/or training animals such as dogs may become a source of financial profit over

and above the vital profit of satisfaction. Collecting is creative in the sense that the collection is self-created, even though the individual items are not. Collecting, however, has the limitation that it is prone to become expensive.

These, and many, many more, are activities for leisure moments which bring lasting satisfactions. Physical vigor, age, values, talents and interests will determine the choice. Enthusiasm is requisite, but it must not be forgotten that enthusiasm grows apace with the challenge of obstacles. It is important that some form of creative recreation be fostered and encouraged in every youth and maiden. Even though these interests may be dormant for years during the period of home building and the struggle for economic safety, the enthusiasm is readily aroused again in the later years of life when leisure is often obligatory. It is much harder to *start* something new after the fifth decade, but by no means impossible. If there is the back-log of interest and the honest evaluation and recognition of the desire, the leisure of old age can bring a wealth of joy. If there is no mental, moral and emotional preparation, the senile is truly sterile. All productivity is not merely biological.

Thus the responsibility for happiness in old age rests upon parents and teachers. Occasionally well-meant efforts at interesting the restless youth of to-day are embarrassing, but more often the rewards are more than worthy of the effort. There was the small boy whose fond and wise mother urged him to try to become interested in some hobby, such as collecting butterflies, moths, stamps or shells and suggested he search the town library for books to start him off. Great was her consternation when he informed her that he had found just the book, called "Advice to Young Mothers."

Growing old gracefully, happily and usefully is an art. This art needs to be developed and studied. Preparation requires forethought. In the coming years, there will be many more people than ever before faced with the problems of investing their leisure. Preventive medicine has expanded the average life span so that it is conservatively estimated that by 1980 more than 40 per cent. of the population of the United States will be forty-five or more years old. It is expected that nearly 15 per cent. will be sixty-five or over. There will be millions of old people and millions more whose activities will be limited by prolonged partial disability from controllable but not wholly preventable chronic degenerative disorders. Can these millions be equipped to utilize their leisure so as to get the full priceless value from their years of harvest and feel that they continue their usefulness? Or will they be burdened by the heavy yoke of boredom, ineffectuality and uselessness? The answer depends upon the preparation they receive in youth. And *now* is the time of their youth. The afternoon and evening of life can be made glorious and beautiful. The gain to the community is immeasurable: cultural values transcend economic measures. The physician interested in geriatrics and the degenerative diseases of late middle life sees the vivid contrast between the misery of boredom in the physically handicapped unable to create their own recreation and the fine courage and happiness of those who have learned to invest their leisure in creative effort.

CONTRIBUTION OF THE CHEMICAL INDUSTRY TO SCIENCE

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MUCH has been said and written during recent years concerning the contributions of science to industry. One is reminded often of the dependence of the electrical industry upon Faraday's discovery of the principle of the electric motor. All recognize the importance to the fertilizer and munitions industries of Haber's finding of a method of fixing the nitrogen of the air.

The time has been when the scientist might say with some of the purists of the last century that he hoped that his researches would have no practical value. This attitude is strangely similar to that of some of our artist friends, cubists, impressionists, etc., who paint purely for their own amusement and pleasure and have no interest whatsoever in pleasing others.

But irrespective of the wishes of individual scientists, science has contributed enormously to the growth and development of industry—in fact, the growth of modern industry is dependent upon the developments of science. It might be argued indeed, with considerable force that the greatest contribution of science to present-day civilization has been to make modern industry possible with all that this means to mankind.

However, I wish to consider now the other phase of this situation, namely, what has industry, and particularly the chemical industry, contributed to science?

In the first place, it should be pointed out that the chemical industry now definitely recognizes its indebtedness to science. The time has been, and not so many years ago, either, when this was not nearly as generally the case in this country as it is to-day. I belong to a small organization consisting of the directors of industrial research laboratories, such as those of the Bell Telephone System, General Electric Company, du Pont, Standard Oil, etc. I have been told by Dr. Jewett, charter member of this organization and head of the Bell Laboratories, that one of the principal reasons for forming this organization in 1923 was to make it more easily possible and convenient for the heads of research laboratories to consult with one another on ways and means of convincing the business heads of their companies of the importance to them of scientific research. To-day this is no longer necessary—bankers and industrialists are thoroughly convinced of the importance and necessity of scientific research. In fact, during the depression of the last decade the support of research by industry increased instead of decreased as might have been expected.

This support has been manifested in many ways. In the first place, industry has established its own research laboratories. According to a recent report of the National Research Council, there were 1,769 of these in 1938. To-day there are more chemists in the laboratories of industry than in those of educational institutions. Much important scientific research work is done in these laboratories; in fact, at least two American industrial laboratories have Nobel Prize winners in them. Reports of much of the work done in these labora-

tories is published in scientific periodicals, or presented before meetings of learned societies. All of this has added to the sum total of scientific knowledge.

Second, industry has supported financially much important research in scientific institutions and universities. The National Research Council reported last spring that industry was supporting 450 scholarships, fellowships and grants-in-aid in American universities and research institutions.

Third, many special chemicals have been prepared in industrial research laboratories and plants to be supplied without charge to investigators in universities, research institutes, hospitals, etc., to aid them in the prosecution of much fundamental research.

Fourth, industries have made available to university research workers their facilities for large-scale operations, often without charge to the investigator.

Fifth, industrial laboratories are often used for biologically and pharmacologically testing the new products of such investigators.

The support given by industry to research in universities and research institutions is affected essentially by the same factors as those that affect all other expenditures of industry. Industry has been defined by Webster as "systematic labor or human exertion employed for the creation of value or wealth." In the first place, industry must consider the probability or possibility of some return on the funds given in support of the research. This need not be considered in terms of an early return, but in keeping with the general purpose and function of industry it should contribute eventually to "the creation of value and wealth."

The possibility of return depends upon a number of factors, one of the most important of which is the patent policy of a university or institution. Industry is more able and willing to provide funds for research if the university research worker or the university may patent inventions and make these available or at least partially available to the industries which have aided them, provided, of course, the institution has first class investigators.

Another factor affecting the support of research by industry is the amount of advice and council on scientific matters that it obtains from the institution receiving grants from it. Still another factor is the amount of aid it may expect from the institution in training and providing first class investigators and helpers for its laboratories and factories.

Industry has been of enormous value to the scientific investigators of Europe. The support has been given liberally and in large amounts to enable scientists in universities and research institutes who are carrying on important work to continue their work. This has been possible to a very large extent because these industries may expect to receive special patent rights in return for the support given.

The important work of Windaus on vitamin D was made possible by large grants from German industries not only of money but of valuable materials and intermediates. Butenandt's splendid contributions to the elucidation of the chemistry of sex hormones would have been impossible without the enormous amount of help he received from a large German pharmaceutical concern interested in his work.

Similarly, Karrer and Ruzicka have been aided greatly by the Swiss chemical and pharmaceutical industry. In France the famous pharmaceutical and organic chemists, Fourneau and Trefouel, have been supported for years by a large French industry. It was Trefouel, you will remember, who with his biologically trained associates in the Pasteur Institute, Bovet and Nitti, was responsible for the discovery of the wonderful

chemo-therapeutic powers of sulfanilamide.

In this country the support given by industry to university research has been extensive, but on the whole has not been as great, at least in proportion to the wealth of the country, as in Europe. This is due partly to the policies of American universities concerning the disposition of their patentable discoveries. The proper disposition of such rights is a difficult problem. Universities are founded for the purpose of diffusing and increasing knowledge. Scientific investigators in general, and particularly those in universities must be interested primarily in these same ends. It is very important to the future welfare of the universities that its scientists hold these primary objectives ever before them, and that they feel free to publish their findings to all the world.

On the other hand if American universities are able to work out a policy under which their primary ends are not sacrificed and at the same time are able to offer those industries which contribute to their research program the chance to receive some reasonable return on the money offered, much important fundamental scientific work may be done which would otherwise be impossible. To-day with the ever decreasing return on endowments and decreasing contributions to universities from wealthy philanthropists the solution of this problem would seem particularly important. From the point of view of society as a whole it would seem desirable also that this problem should be solved satisfactorily and soon, if we do not want all of our universities to be dependent upon government money for their support, or to sacrifice their research programs. Much good constructive thought is being given to the problem to-day both by the industries and the universities, and a satisfactory solution will surely be found.

During the rest of this paper I wish to describe something of the research work supported by one American chemical industry with which I am connected. This industry has its own research laboratories for chemical, physical, bacteriological, pathological and pharmacological research, and helps support scientific work, including clinical studies in a number of universities, research institutions and hospitals located in various towns and cities from one end of this land to the other. Most of the problems on which work is being done in the laboratories of this industry are carried on, at one stage or another, in cooperation with investigators in outside research institutions.

In 1930 it was suggested by Professor Chauncey Leake, of the University of California, that unsaturated ethers such as vinyl ethyl ether ($CH_2 = CHOCH_2CH_3$) and divinyl ether ($CH_2 = CHOCH = CH_2$) might be good general anesthetics. This assumption was based on their chemical relationship to two successful anesthetics, ethyl ether ($CH_3CH_2OCH_2CH_3$) and ethylene ($CH_2 = CH_2$). A number of unsaturated ethers were made by known methods and tested in Professor Leake's laboratory. The most promising of these was found to be divinyl ether. Methods were developed in our laboratories for preparing this ether in a pure state. It was soon found that the product was unstable, forming aldehydes, acids and polymers on decomposition; it was necessary to find a way to prevent this. Success was achieved finally by the addition of a small amount of a relatively nontoxic, non-volatile oxidation inhibitor to the ether. Difficulty was caused because of the tendency for ice crystals to form on the anesthetic mask as the ether was administered, interfering with the normal flow of air to the patient. This was due to the cooling effect produced by evaporation on the divinyl ether, which boils at 28.3° C. This obstacle to

the use of this ether as an anesthetic was overcome by the addition of 3.5 per cent. alcohol to it. The new anesthetic mixture of divinyl ether, alcohol and inhibitor was named Vinethene. Its value as an anesthetic for dogs was studied extensively by Professor Ravdin and his co-workers at the University of Pennsylvania. After satisfying themselves as to its safety, they introduced it into their clinics for humans. They were much pleased with the results obtained. Pharmacological work on the product was done also in California and in the Merck Institute in Rahway. The use of the product spread to various hospitals in this country and Vinethene was accepted by the Council on Chemistry and Pharmacy of the American Medical Association. To-day it is used as an inhalation anesthetic for short operations in all parts of the world. Incidentally, it may be mentioned that it has proved particularly useful to military surgeons for short operations in field hospitals.

A number of years ago, we collaborated with one of the veterinary schools in a search of anesthetics and analgesics for large animals. In the course of this work we became interested in curare. Curare is a crude pitch-like mixture which is made by South American Indians for use as a poison for the tips of their arrows. Different tribes of Indians make their curare in different ways and it is not always made even in the same way by the same tribe. For this reason curare varies enormously from one lot to another. Until very recently it has been used only experimentally by biologists and pharmacologists in order to produce a unique and characteristic paralysis of the muscles of animals into which it is injected. This effect is due to its action on their motor nerves. Within recent years the medical profession has found a limited use for a biologically standardized preparation of curare of high potency in the treatment of tetanus, convulsions from strychnine poisoning and spastic paralysis. Due to the difficulty of obtaining a dependable supply of potent yet relatively non-toxic curare and because of the variability in its composition, the rational use of curare for therapeutic purposes appears to hold very little promise.

During the course of our studies of curare it was found by a California investigator that an extract of the beans of *Erythrina americana* had a curare-like action. This observation was checked in our laboratories and an effort was begun to isolate the active principle. Eventually, this was found to be a mixture of two stereoisomeric alkaloids which have been named alpha and beta-erythroidine. In view of the activity of the alkaloids of *Erythrina americana* it was decided that other species of *Erythrina* beans should be extracted and the active principle isolated and pharmacologically studied. Accordingly, a large number of species of *Erythrina* were obtained from South and Central America, the Philippines, Africa and other parts of the world. Several new alkaloids have been isolated from these species; all of these appear to be related chemically to erythroidine. All of them, also, have some curare-like action but, curiously enough, beta-erythroidine, itself, seems to be the most satisfactory for therapeutic use. It is being investigated now in a number of medical clinics with promising results. It has the advantage over curare that it is effective not only on parenteral injection, but also when taken by mouth; but most important of all, it is of known and constant composition and does not vary in activity from one lot to another as does curare.

I wish to speak, finally, of the interest in the vitamins which we have had in recent years, and of our work, in collaboration with a number of outside investigators, with these fascinating essentials of the animal diet and, in many in-

stances, plant diet as well. First, I shall speak of vitamin B_1.

It will be recalled that in 1897 the Dutch investigator, Eijkman, working in Java showed that a paralytic disease of fowls resembling human beriberi could be cured by the addition of rice polishings to their diet. Later other scientists showed, definitely, that human beriberi is due to a deficiency of some substance in the diet that is found in rice polish, yeast and meat and that it may be cured by feeding such foods. This dietary constituent, which has been termed vitamin B_1, was isolated in 1926 by Jansen and Donath, who were also working in Java. In 1934 Dr. R. R. Williams and his co-workers in the United States published a new improved method of isolating the vitamin, and early in 1935 Williams offered a tentative chemical structure for it. He had begun his work on vitamin B_1 in the Philippines almost twenty-five years earlier. This work has been continued since that time in spare moments taken from the requirements of an active professional career. Help for the continuation of the investigation was obtained from a number of sources, including university departments and philanthropic foundations.

In 1935, Williams requested help from us, first in the preparation of larger quantities of vitamin B_1 for use in studying its structure; second, by scientific collaboration in his study of its structure and eventual synthesis, and finally by making biological assays which were necessary for the success of the investigation. As a result of the cooperation into which we entered, the structure of the vitamin was established definitely and it was synthesized in our laboratories in 1936 by Williams and Cline. Incidentally, it was synthesized also by Todd and Bergel in England and by Andersag and Westphal in Germany at about the same time.

This synthesis has made it possible to make vitamin B_1 in large quantities and to sell it for a few dollars a gram. Previously, it had cost several hundred dollars a gram to produce it from rice polish, which is the most satisfactory natural source. This vitamin is now used in increasingly large quantities for man and animals in the cure and prevention of beriberi, neuritis of various types, cardiovascular disturbances due to certain dietary deficiencies and for loss of appetite. Recent studies have shown that vitamin B_1 deficiency is more prevalent in the United States than has been supposed.

Also vitamin B_1 is of value for the stimulation of the growth of plants and particularly of their roots. It appears probable that considerable quantities of it will be used in horticulture.

Another vitamin on which we have done a large amount of work is vitamin B_6. The existence of this vitamin was first postulated by György in 1934 who showed that rats which had plenty of the then known dietary constituents, including vitamin B_1 and B_2, developed characteristic lesions of the skin. They could be cured by the addition of rice bran, yeast or liver to their diet. In 1937 Keresztesy and Stevens in our laboratories, Lepkovsky in California, György in Cleveland and Kuhn in Heidelberg reported the isolation of pure vitamin B_6, or Factor 1, as it is called by some. In 1939 the structure of the vitamin was definitely established and its synthesis was accomplished in our laboratories. It was synthesized also by Kuhn in Germany.

As has been mentioned, a deficiency of this vitamin in the diet of rats is associated with a severe dermatitis. It has been found also that a severe type of anemia develops in puppies when vitamin B_6 is the only missing component in the diet; this anemia may be cured by the addition of this factor to their diet. Investigators in many parts of the world

are studying its value in the treatment of human beings.

Yet another vitamin with which our laboratories have been concerned is vitamin E. About fifteen years ago several investigators began to suspect the existence of a specific vitamin required for normal fertility, at least in the rat. The positive existence of such a vitamin, termed vitamin E, was proved by Herbert Evans and his co-workers at the University of California. In 1936–1937 Evans, and his associates, the Emersons, reported the isolation of three comopunds from the oils of the germs of various seeds and grains which had the properties of vitamin E. These compounds were termed alpha, beta and gamma-tocopherol. They were all oils which had hydroxyl groups in their molecules and which formed crystalline allophanates. The most active of these was alpha-tocopherol. It may be isolated fairly readily from wheat germ oil or cottonseed oil.

In 1936 Evans enlisted our cooperation in the preparation of larger quantities of alpha-tocopherol than could be made very well in an academic laboratory. This was required first for chemical studies of the structure of the vitamin, and second for further investigation of its physiological action. Studies on the structure of alpha-tocopherol were begun, in 1936, in our laboratories. In 1937 Fernholz reported from these laboratories that it was probably a derivative of durohydroquinone and early in 1938 published the first correct structure of the vitamin. The correctness of this structure was confirmed by Karrer, John, Todd, Smith and others.

Very early in 1938 we enlisted the cooperation of Lee I. Smith at the University of Minnesota in the synthesis of alpha-tocopherol. This was done partly because Fernholz had accepted an appointment to another laboratory, and partly because Smith had had a great deal of chemical experience with durohydroquinone and related compounds and was in a position to make almost immediate contributions to the synthesis of the vitamin. He accomplished this in a relatively short time. He has synthesized it, also, in a number of other ways. In addition to this, it has been synthesized by a number of European investigators, particularly Karrer and Todd and their co-workers. The other two tocopherols have been shown to be the next lower homologues of alpha tocopherol, having only two methyl groups on the benzenoid nucleus.

The therapeutic value of alpha-tocopherol has yet to be definitely established, but there are indications of its value in the treatment of certain types of abortion in man and animals. It has been shown recently also that deficiency of vitamin E in the male is associated with certain degenerative changes in the testicles. In addition, lack of the vitamin in the diet produces certain types of muscular dystrophy suggesting its possible value in the treatment of some types of muscular disturbances in the human.

Finally, I wish to say something about vitamin K, the latest of the vitamins to yield the secret of its structure to the chemist. About ten years ago the Scandinavian investigator, Dam, found that the blood of chickens clotted very slowly if their diet was deficient in a specific, fat-soluble substance. The presence of this substance in fish meal and alfalfa was demonstrated by several research workers. This was done by feeding these foods to chickens whose blood clotted slowly because they were fed a diet deficient in this factor. This factor has been named vitamin K.

In 1936 Almquist in California reported the preparation of a concentrate of vitamin K from alfalfa of which 2 milligrams formed a sufficient supplement for one kilogram of feed.

Last year Karrer in Switzerland and Doisy in this country announced the isolation of pure vitamin K in the form of an oil from alfalfa. Doisy called this vitamin K_1 since he was able to isolate another compound with similar action from fish meal which he termed vitamin K_2. In this work Doisy was aided greatly by one of the great pharmaceutical houses, Parke, Davis & Co.

Based upon its absorption spectra and on certain other properties, Doisy concluded that vitamin K_1 might be a quinone. Soon after this Almquist, with whom we had cooperated by supplying him with vitamin K_1 extracts from alfalfa, showed that phthiocol, a product which had been isolated from tubercle bacilli by R. J. Anderson, and of known chemical structure, had vitamin K activity. A number of research workers quickly came to the conclusion that vitamin K was a napthoquinone derivative. By a brilliant series of experiments and studies in several American laboratories, the structure of vitamin K_1 was definitely determined in the summer of 1939.

It was synthesized by Doisy, Almquist and Fieser. Fieser entered this field as a result of his considerable experience with quinones and particularly naphthoquinones. This had led him to conclude that vitamin K_1 was a naphthoquinone derivative. Soon afterward, he came to the conclusion that the vitamin had the determined structure and he decided to try to synthesize it. His synthetic product was tested biologically in the laboratories of the Merck Institute and found to be active. It was compared with a sample of natural vitamin K_1 for the preparation of which he had developed a novel and easy method of extraction from alfalfa. The synthetic and natural vitamins were found to be the same.

It is of interest to note that a number of other naphthoquinones have vitamin K activity but, more curious, that one of these, 2-methyl-1, 4-naphthoquinone, is more active than vitamin K_1 itself. As far as we know, this compound does not occur naturally. Some synthetic compounds chemically related to the other known vitamins have an action similar to these vitamins, but in all other cases the natural vitamin, prepared either from natural sources or else synthetically, is more active than any of the synthetic substitutes.

Although vitamin K has been known only a comparatively short time, it has already been found valuable in medicine for the prevention of certain types of bleeding. In a number of hospitals it is given pre-operatively to certain patients who show low prothrombin levels in the blood, since under these conditions the blood clotting time is slow. Also, it is being given to new-born babies who often suffer from too slow coagulation of the blood, due to deficiency of vitamin K. Much additional work is being done in an effort to determine definitely the place of this vitamin in therapy.

In conclusion, I wish to call attention again to the benefits that science has received through its cooperation with industry. I hope that further and extended cooperation of this type may be possible in the future, not only for the benefit of science and industry, but also for the benefit of society in general.

DISTRIBUTION OF FRESH-WATER FISHES IN THE INDO-PACIFIC

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The belief in lost continents is one that persists in the minds of many people. Individuals without the slightest knowledge of geology, botany, zoology or anthropology—in fact, without specialized knowledge of any kind—cling to their beliefs in fabled Atlantis or the still more mysterious and shadowy continent of Mu.

For many generations people have been puzzled by problems in the distribution of plants and animals, including man himself. In addition, the buildings and other structures of prehistoric time, the artifacts, customs, myths, legends and cultural developments in many parts of the world have presented innumerable vexatious and well-nigh insoluble questions to perplex and mystify the learned, as well as the ignorant.

To these puzzles there have been and still are all sorts of reactions, but two stand out far beyond all others. One is to trace the origin of all culture or cultures and all human achievement back to Egypt. The other is to stick a large and convenient land mass into the middle of the Atlantic, the legendary Atlantis, or over a large part of Polynesia, the imaginary lost continent of Mu.

Many a student of plants or of some particular group of animals has been so sorely puzzled by the distribution of the forms studied that he has taken refuge in the idea of a great land mass that has long since vanished. To explain the distribution of certain organisms in Australia, New Zealand, South Africa and the southern end of South America, many persons have believed they were once in contact and have since drifted apart, or were connected by a land bridge or continent that has since disappeared. Particularly puzzled by the distribution of various forms in the Indo-Pacific realm, various workers have invoked the aid of a lost or sunken land mass over a a large part of what is now Polynesia. All sorts of organisms have been utilized in an attempt to show that their distribution has been due to some great land mass in the tropical Pacific, some continent or island of incredible vastness, which eventually disappeared beneath the sea.

If an animal is found in widely separated and unconnected localities, or closely related animals occur in such regions, we may assume that such places have been connected at some period more or less remote. That is to say, we may make such assumptions provided the organisms concerned can not fly or be borne about by the wind, are not carried about by man or other animals or attached to or within plants, and can not live in the sea for more than a very short time. Then before such assumptions receive credence they must be corroborated by geological evidence and further supported by additional data concerning other organisms, either plant or animal, or both.

Among the best organisms for the determination of former land connections are the fresh-water fishes. However, the term "fresh-water fish" must be applied with discretion. Not all fishes found in fresh water are entitled to be called true fresh-water fishes. This is conspicuously the case in some parts of the world.

Every one naturally and readily separates the fishes of Europe, northern Asia

and North America into two great groups. The one included all those that are marine, the other those that spend their lives in fresh water. While it is true that a number of well-known fishes are on the border line, or spend a part of their lives in the sea and a part in fresh water, there is never any real confusion in distinguishing one from the other. With the exception of salmon, some trout, alewives, fresh-water eels, and a very few others, the fishes of the regions cited spend their lives in either fresh or salt water. They may venture from one side or the other into brackish water and take up permanent residence there, or they may live in either fresh or salt water or in brackish water, but a very few venture into all three or live indifferently in all.

The case is very different when one enters the tropics. There the student of fishes is confused to find marine fishes living freely in fresh-water lakes and rivers, while in some regions the entire fresh-water fish fauna is really composed of marine fishes. This is true of the American tropics to a certain degree, but is characteristic of a large part of the Indo-Pacific realm.

This region contains very few families of fishes that are exclusively fresh water. The only ones of real importance are the Cyprinidae, the Ophicephalidae, the Anabantidae, several families of catfishes and the Mastacembelidae. Other families of true fresh-water fishes contain few species of small importance, except in Africa and South America. There the Characinidae, the Cichlidae and the Cyprinodontidae are very numerous and important. In the American tropics there are no cyprinids, their place being taken by characins.

In the rivers and lakes of the eastern and southern coast lands of Asia dwell an immense number of Cyprinidae, in a bewildering variety of species. Many kinds of catfishes, belonging to at least eight families, also inhabit these same waters. The other families mentioned are far more limited in their number and their variety of species. Of them all, the cyprinids are perhaps best suited to demonstrate the principles of zoogeography.

The great islands lying off the southeast of Asia also swarm with cyprinids, while catfishes, labyrinth fishes and mastacembelids likewise thrive in their waters. The geological evidence and the presence of identical species of cyprinids, labyrinth fishes and catfishes on the mainland of Asia and in Sumatra, Java, Borneo, Palawan, Mindanao and smaller islands along their coasts are sufficient to prove that these islands were once all connected and formed a part of the mainland. Together they formed the Sunda Land of Mollengraf. In addition, there is plenty of other evidence, botanical and zoological, to demonstrate the extent and validity of Sunda Land.

In addition to the true fresh-water fishes mentioned, many other kinds of fishes occur in the fresh-water streams and lakes of eastern and southern Asia and the great islands mentioned. One encounters sharks, snappers, mullets, sea-bass, Carangidae or crevalle, threadfins, Chanidae, tarpon, marine eels and Scatophagidae, just to mention a few, in strictly fresh-water rivers and lakes. They are found not only in the lower courses of rivers and in lakes near the sea, but often occur hundreds of kilometers from the sea. Some kinds seem to make but a brief excursion into some river and lake, while others remain a season or longer, up to several years, until they reach maturity and are almost ready to spawn before they start back to the sea. Often the number of a given species living in a certain lake or river may be very large, and give rise to important fisheries, but it is really only a small part of the total population of the species, the vast majority remaining in the sea.

None of the true fresh-water fishes

has succeeded in passing from Borneo to Celebes across the narrow but deep Strait of Makassar. One small cyprinid has passed from Bali to Lombok, but none of the other true fresh-water fishes has gone east of Wallace's line, which runs along the deep but very narrow strait east of Bali and continues northward through the Strait of Makassar.

On Celebes, Amboyna, Halmahera and perhaps others two true fresh-water fishes are found, but it is well known that they have been taken there by man. They are both labyrinth fishes, the climbing perch, *Anabas testudineus,* and a snakehead or murrel, *Ophicephalus striatus.* Both species have been very widely distributed by wandering Malay fishermen, and their presence in the East in the waters of an island is no proof of their being native there.

When one passes east of Wallace's line and enters the rest of the East Indies and the Philippines east of Palawan (which is included with Wallace's line), and passes eastward into the Pacific, a different world is entered so far as true fresh-water fishes are concerned. The streams and lakes are abundantly supplied with fishes, and a fair proportion spend all or most of their life in fresh water. There is an even greater variety of marine fishes in the fresh waters of this part of the tropical Pacific, while the apparently strictly fresh-water fishes are all members of families that are for the most part inhabitants of the sea. They are therefore recent migrants into fresh water which they found unoccupied by other fishes.

Characteristic of the streams and the lakes of Luzon are its fresh-water gobies, which occur in a bewildering variety. Most of them go down to the sea to spawn, though some, especially those found only in lakes and in mountain brooks, spend their whole existence in fresh water. To a lesser degree the same is true as one goes eastward and southward throughout the tropical Pacific. Those gobies which now remain permanently in fresh water, like the minute ones in the lakes of Luzon, are immigrants from salt water in recent geologic time.

Certain pipe-fishes and half beaks are also found very widely distributed in the fresh waters of the Indo-Pacific region. At least two species of Kuhlia, bass-like fishes of moderate size, are likewise in streams everywhere in the region. All these are marine fishes recently adapted to life in fresh water, and are able to survive long journeys in salt water. In some cases the fry, in others the adults are able to live in salt water for considerable periods. Therefore these and other fishes of recent migration to fresh water occur in suitable localities in the Pacific, even to the far-off Marquesas.

It is accordingly unnecessary to assume a lost continent, or to imagine great land masses covering parts of Polynesia and Micronesia, to explain the distribution of the fishes occurring in the fresh waters of the region east of Wallace's line. Any one who has fished by electric light at night in the East Indies or some Polynesian archipelago knows that a surprising number and variety of the fishes living in fresh water are dipped up as they float by in the tidal currents.

Once it was assumed that New Zealand, Australia, South Africa and the southern end of South America were all connected at some past era. This was because fishes of the genus Galaxias occur in the fresh-water rivers of all those regions. Later it was shown that Galaxias is able to live in salt water, and has migrated from the sea to fresh water in recent geologic time. The hypothesis of a land bridge to account for the distribution of this fish therefore vanished.

In the fresh waters of Australia, New Guinea, and some of the small islands

about and between them, and in Celebes, occur certain genera of fresh-water fishes which belong to the family *Atherinidae*. This family is largely composed of small temperate and tropical sea fishes, which have become adapted to living permanently in the sea. One group, probably developed in Australia, became distributed when New Guinea was a part of Lemuria, the land mass which included both Australia and New Guinea. Two other genera are found only in Celebes, which has evidently been cut off from other land areas for a very long time, so that all its fresh-water fishes are recent migrants from the sea, as is likewise the case in New Guinea.

As far as the evidence from fresh-water fishes applies, we may dismiss all idea of a lost continent in Micronesia or Polynesia. Wallace's line marks the eastern limits of the fresh-water fishes of Asia.

GALILEO AND THE MODERN WORLD

By RUFUS SUTER
LIBRARY OF CONGRESS

I

Galileo Galilei, whom most of us remember as the Italian who dropped balls from the top of the Leaning Tower of Pisa, was the first man in modern history to picture the universe as a machine. Proceeding from this new point of view, he discovered many laws of nature—among them the principle of the pendulum, the laws of bodies in equilibrium and of bodies falling, whether dropping freely, rolling down inclined planes, or flying through the air as projectiles. And he established also a few principles concerning the action of lodestones.

Once Galileo had shown the way, people who were curious about nature continued to think and proceed according to the pattern he had outlined. With his example of the kind of knowledge to seek, they discovered the rules or regularities involved in the conduct of gases under pressure, of light and heat, of sound, of chemical combination, of steam, of magnetism and electricity. The process of discovery has been advancing now for more than three centuries and its possibilities are not exhausted. In the meantime, civilization in Europe and America has been transformed from its roots to its highest branches, and the older cultures of Asia are following.

This Italian scientist, in other words, by teaching us a fecund conception of natural law and a fruitful method of interrogating nature, became one of the most influential among the thinkers and men of action who have given us the modern world. We may meaningfully ask: If he had not lived would we to-day have our giant bridges and skyscrapers, our railroad trains and radios? His importance is such that we should be as well informed about him as we are about the most intrepid explorers and acutest scientists of to-day.

Galileo was an inventor. Contrary to popular opinion, however, the only instruments of which he was literally the originator were the pulsilogia and the sector. The former, based upon his discovery that the pendulum is a regulatable and dependable timekeeper, was a machine for measuring the pulse beat. It proved to be more of a curiosity than a fruitful suggestion to medicine, but it was the forerunner of the pendulum clock, a drawing of which was the last device he diagrammed before his death. His other original invention, the sector

(or military and geometrical compass), was a mathematical instrument of use to architects and surveyors and, financially, was the most successful of his instruments.

The devices popularly attributed to Galileo: the telescope, microscope, air-thermometer, the hydrostatic balance (for determining the specific gravity of bodies) and the armature (for increasing the power of magnets) were not actual inventions, but in each case marked a vast improvement over anything which had preceded them. His strongest telescope, for example, magnified about thirty diameters, whereas the original telescope, made in the Netherlands, was a mere plaything.

Another of Galileo's inventions—a method rather than an instrument—was a means for determining longitude at sea. Although for centuries navigators had been able to compute latitude (it was simply a matter of taking the difference between the altitude of the Pole Star and 90°), the problem of longitude was much more difficult. Several European governments, appreciating the practical importance of a solution to this riddle, offered prizes for suggestions. Galileo proposed to enlist in the service of navigation the four moons of Jupiter which he had discovered. His idea was this: If ephemerides of the Jovian satellites were drawn up for Florence—a task to which he devoted many years—an eclipse, for instance, of one of these bodies as seen from Florence could be predicted to the hour and minute. Then out at sea, in a different longitude, the navigator would only need to figure the difference between the time at which he had observed the eclipse and that predicted by the Florentine tables in order to have a basis for determining his longitude. The longitude of Florence could be taken as zero. Since the earth turns at the rate of fifteen degrees per hour, the difference between the two times multiplied by fifteen would give the longitude of the ship. This method was theoretically possible, but practical difficulties rendered it useless. In the first place there were not yet clocks that would keep the time from one noon to the following evening with sufficient accuracy. In the second place, it was impossible to make precise observations of Jupiter's moons from the rolling deck of a ship. Galileo had ideas for overcoming both these difficulties: he proposed the use of the pendulum as a timekeeper, and he devised a telescope which could be worn by means of a frame on an observer's head and shoulders while the observer sat in a chair floating in a tub of water on the ship's deck. But the time was not yet ripe for the solution of the problem of longitude. Of all the governments with which he negotiated, only the Tuscan gave his scheme a trial, and that to no avail. The kernel of his idea, nevertheless, was suggestive. Not Florence but Greenwich afterwards became the baseline for longitude; not a pendulum clock but the ship's chronometer was developed; ephemerides not for the Jovian satellites but for the sun, moon, planets and stars were published for the use of navigators by most of the important maritime powers of Europe.

All in all, if Galileo had been an inventor only he would have been as outstanding a figure in history as Edison. But as fortune had it he was more than an inventor. The evolution of any mechanical device from the primitive stage to that of most usefulness requires a special climate. The latter is indispensable, for without it, an invention—no matter how promising—is bound to die sterile. Galileo was remarkable in that he combined in himself both practical, inventive, technical genius and profound insight into abstract science. Thus he was able not only to plant many

seeds, but also to aid in developing a climate of abstract thought highly conducive to their growth.

II

If we remember Galileo as the Italian who dropped balls from the top of the Leaning Tower of Pisa, we may also recall him as the man who irritated the Roman Inquisition by holding that the earth spins on an axis and swings around the sun. We can not grasp the significance of his contribution to abstract thought until we have understood the church's as well as his side in this famous dispute. The issue cut far deeper than any mere question of whether the earth moves.

We should remember that for a thousand years Europe had grown up under the guide strings of Catholicism. Under her tutelage the Teutonic barbarians from the north, who had been instrumental in breaking up the ancient Roman Empire, had been civilized and a political and intellectual unity of Europe had come into being which has never since been paralleled. There had evolved a marvelously stable social and economic structure and a code of law and morals which every responsible person regarded as God-given. This structure and code people believed were intimately connected with the picture of the universe in the Old Testament and in the Christianized version of the Greek philosophers, Plato and Aristotle. In those books was the whole truth. Whoever doubted them was undermining the nethermost foundations of society. An innovator was seen in the same light as we to-day would regard a communist and atheist.

If we wish to characterize in a word the picture of the world which our medieval ancestors and which most of Galileo's contemporaries held sacrosanct, the least we may say is that for them the universe was a moral and legal order.

It will also help us to understand the antagonism between the ecclesiastical authorities and Galileo if we recall that the century in which he lived was witnessing the death struggle of purely Catholic conceptions as dominating the European scene. To the Pope and cardinals who condemned Galileo the pillars of civilization must have seemed to be collapsing. Protestantism in religious affairs and nationalism in politics (both denials of the ideal which Rome had spent a millennium in upbuilding) were gaining ground. The Moslem Turks were making trouble in Austria and Hungary. The Thirty Years' War was raging. Old cultures, thoroughly developed but strangers to the influence of Christianity, were being discovered. People were sailing to lands 10,000 miles away: the Americas, India, China, Japan, Australia. Then in the midst of this turmoil Galileo arose and from another angle threatened to knock the bottom out of the painfully won thought-structure of conservative men. The Pope and cardinals deserve admiration for having appreciated that the apparently remote, academic cogitations of an abstract scientist could play a devastating rôle in the chaotic world of practical affairs.

What was the revolution which Galileo championed? He was perhaps the most effective personality in the small group of men who in the sixteenth and seventeenth centuries began to re-think the basic features of the universe so that physical science could evolve. By "physical science" we mean science as we know it now: a deliberately planned, organized, systematic body of knowledge about physical things capable of providing us with the means of making predictions and thus of controling nature on a vast, cooperative scale. Galileo, in other words, ignored the traditional and respectable view that the laws governing the universe are literally *laws*—judicial

and moral statutes and rules asserting a fitness and usefulness in things. Instead, he was the first among modern men to begin to think in terms of an un-judicial, non-moral, de-humanized kind of law. He switched from the vision of the world as the unrolling of a legal mind to that of the universe as an intricate system of cogs, pulleys, levers, tops, balls rolling down inclined planes, pendulums, magnets and shifting geometrical figures.

The object of the student of nature, as Galileo began to conceive it, was the same as that of the tester of a machine: to approach it, in the first place, knowing full well that it is a machine, and hence to be able to anticipate, to a degree, the kind of conduct in process; then to watch the machine run, with a clock, compasses and gauges, a ruler, a magnifying glass, etc., at the fingers' tips. The information to be obtained was accurate measures of size, speed, direction of motion, weight, number and arrangement of parts.

Galileo's conception of method may seem self-evident to us. We may find it difficult to grasp the length of the leap which he took. But after his time the student of nature was no longer a scholar comparing texts of Aristotle, no longer a mystic trying to decipher the attributes of God as symbolized in natural phenomena, no longer even a simple man of common sense seeking to understand *why* or *for what purpose* water flows down hill, earthquakes occur and grass is green. The student of nature became a technician, asking and answering only one question: "*How* does this or that contrivance in nature work?" and the aim was to frame a reply in mathematical notation.

Galileo's inventions were important. His discoveries with the aid of his telescopes were important. One always remembers with a shock that he was the first human being to know that the moon is a world with mountains and plains, that Venus has phases, that the sun has spots and rotates, that Jupiter has moons, that the Milky Way is a throng of stars. But immeasurably more significant for later history than any of his inventions or discoveries were his picture of nature as a machine and his conception of scientific method as a super-refined empirical examining of the parts of the machine to unravel regularities in its operations—regularities which one knows in advance to exist, because such is the nature of a machine, but which one does not know specifically. From this point of view has come the body of physical science, theoretical and applied. From this body has sprung our modern industrial civilization.

SOME ECONOMIC REPERCUSSIONS OF MEDICAL PROGRESS

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I

THE habit of over-simplification is probably the most wide-spread of our present-day intellectual depravities. With their heads as well as with their hands people are trying to get results with the least exertion. One need only listen to popular discussion on any nation-wide problem to see with what marvelous ease the practical difficulties are brushed away. Situations which have evolved from the interaction of many complex forces are relegated to a single cause in this process of wishful thinking. Thus we find the economic vicissitudes of the modern world attributed to mass production, the machine age, the profit system, the burden of taxes, the breakdown of international commerce or to some other simple origin which can be compressed into a single phrase. It betokens the impatience of the public mind with any and all explanations that can not be reduced to a formula.

Yet it ought to be self-evident that a great many forces and factors have combined to throw the world of to-day off its normal economic balance. No one of them could possibly have done it. The interplay of several has been required to do the job. Nor are our contemporary troubles the outcome of forces which began to operate during the past few years, or even a whole generation ago. Some of them have been gaining momentum for over a century, ever since the days of the industrial revolution. Others began to operate much later but have gained strength so rapidly as to make up for a belated start. Long ago it ought to have been realized that these developments were destined to compel great changes in our economic life and organization, but for the most part, the omens were ignored. Now the world is hurriedly trying to figure out what happened to it.

One thing, at least, of far-reaching importance has happened to it during the past hundred years or thereabouts. The population of this planet has doubled during that time. There are about a billion more people on the earth to-day than there were in 1840. Malthus would have flatly declared that no such increase could possibly take place in a hundred years or even in several hundred years. The pressure on subsistence would have stalled further increase, according to the Malthusian law, long before the doubling point could be reached. Yet it has been reached, and if the rate of growth is now slackening somewhat, it is not because there is too little food to go around. In America there is too much. That is one of our troubles. If you doubt it, ask any farmer.

Where Malthus erred was in assuming that, so far as his capacity for economic production goes, man is a machine of relatively fixed output. Advances both in technology and in medical science have shattered that assumption. The growth of population has been outstripped by increased efficiency. But when we talk about the Machine Age, let us not overlook what has happened to the *human machine* through its increased life expectancy, greater freedom

from illness, more rapid recoveries from injuries and improved physical vigor all along the line. Comparative figures of population do not tell the whole story. World population has doubled in a century, but in its ability per capita to utilize the resources of the earth it has done a great deal more than that.

The productive capacity of the two billion human beings who inhabit the globe at the present time is several times that of the one billion who dwelt upon it at the beginning of the Victorian era. This, of course, is primarily due to the way in which machinery has been brought to the aid of man. Steam and steel have taken over tasks that strained the muscles of millions. But in considerable measure our enormously increased economic productivity results from the fact that man, on the average, is himself a far more efficient mechanism than he was a century ago. Inventors and engineers have done their share; but the service rendered by medical science to the augmentation of human efficiency is something that should not be overlooked in any discussion of such economic problems as overproduction and unemployment.

Even a hundred years ago, a large portion of the earth's surface was unable to produce anything beyond the needs of its own inhabitants. These areas had as much in the way of natural resources as they possess to-day, but their possibilities remained undeveloped because the white man's leadership was lacking. Plagues and pestilences, such as malaria, yellow fever, typhus and sleeping sickness, made it virtually impossible for white men to live for any length of time in tropical and semi-tropical regions throughout most of the world. But during the past half century the progress of medical science has established human mastery over these scourges, and vast tropical areas have been enabled to increase their productivity many times over. One can realize on a moment's reflection, for example, what the conquest of malaria and yellow fever has meant to the production of sugar in Cuba, fruits in Central America and coffee in Brazil. It is not new methods of agriculture but progress in disease eradication that has brought Egypt and the Soudan into the world's cotton market and made the west coast of Africa a great producer of crude rubber. There is hardly a great staple of trade which has not had its world supply increased during the past fifty years by the opening up of regions which could not be exploited earlier because of their inroads upon the lives and health of the people. All this, quite naturally, has had its repercussions in fields of diplomacy and international competition. What used to be known as the waste places of the earth are now coveted by nations which regard themselves as overpopulated or lacking in natural resources.

We speak of the Panama Canal as a great triumph of engineering skill. What it has meant to the development of seaborne commerce between the two coasts of America and between Europe and the Orient is something that needs no elaboration here. But no amount of engineering skill would have availed to build that waterway had it not been for the marvelous advances in tropical medicine which preceded the work. It was not the invention of the steam shovel but the conquest of malaria and yellow fever that made it possible for Goethals to succeed where his French predecessors had failed.

II

Of all the plagues that have afflicted the world in the course of human history, it is probable that malaria has taken the largest toll. Not that it has been so virulent and periodically devastating as

some others, such as bubonic, but its incidence has covered the tropics, the semi-tropics and even the southern portion of the temperate zones. No other disease has been so persistent for at least twenty-five hundred years. The Athenian empire counted malaria its worst and most implacable enemy. If Athens could have conquered malaria she would have ruled the world. Rome, too, was scourged by malaria throughout her history. It carried off more of her soldiers than were slain in all the wars that Rome waged with her neighbors. Situated in a low, marshy area, the City of the Seven Hills was hounded by "fever" as regularly as every summer came, and the eventual emaciation of the people in this imperial capital must be reckoned as one of the causes of its collapse.

The Roman authorities put forth great efforts to discover the cause of malaria and, as a matter of fact, came nearer to success than they realized, for they became convinced that it was a "pestilence that walketh by night." It was a disease borne by the night air. Hence the best way of avoiding the infection was to close the windows and doors of every house tightly from sundown to sunrise. Correct procedure this was, so far as it went, but no Roman had ingenuity enough to take the next step by suggesting a possible relation between night air and mosquitoes. Not for fifteen hundred years after the fall of Rome did the world place its finger upon the *Anopheles* as the real source of the trouble.

It is true that the mosquito had been under suspicion for a long time, but guilt could not be definitely fixed upon his tribe as a whole. Long and patient experimentation was required to find out that among the hundred or more species of mosquito, only a very few ever carry infection from one human being to another, and that even among these it is the female alone which can carry it. The process of infective transmission, moreover, requires a certain interval of time, and the problem of determining this was one that long baffled the investigators. Even after the route of infection became definitely established, there was considerable difficulty in convincing the public authorities and the people of tropical areas that malaria and yellow fever could be brought under control by eliminating mosquitoes at their source, more particularly by the use of oil on the surface of stagnant waters. When the Rockefeller Foundation, for example, undertook to help this work of mosquito eradication, there were millions of people quite ready to believe that the whole thing was merely a scheme to enlarge the market for Standard Oil.

Bubonic was for many centuries the most spectacular of the great plagues. The probability, is, however, that estimates of bubonic mortality have been exaggerated. The Black Death of 1348–1351 is said to have carried off from a third to a half of the English population. And it is true that in some of the English monasteries, where records were carefully kept, the mortality did reach that proportion. But the ratio of deaths among residents of the monastic establishments would naturally be larger than that among the people as a whole. The monks had the duty of visiting the sick and administering the last rites of the Church to the dying. They were exposed to direct infection in doing so. And since they lived together in the monastery the opportunities for spreading the plague among themselves were abundant. In the rural areas where the people were scattered and had little contact with the towns there was a far better chance of escaping the ravages of bubonic, and it is altogether probable that the death rate in such communities was much lower.

Nevertheless, the successive waves of bubonic which swept over Europe during the long stretch between the twelfth and the eighteenth centuries were not only decimating in their effect on human life, but they left large numbers of people weak and enfeebled. Unlike malaria, which took its largest toll from the countryside, bubonic wrought its principal devastation in the cities, especially in the port cities to which the sailing vessels brought their supply of flea-infested rodents from Asia. Down to the close of the seventeenth century it is improbable that any European city had a death rate below its birth rate, even though birth rates were high. When cities grew, it was wholly because of migration from the rural districts.

So it was the progress of medical and sanitary science that made large cities possible. If the major routes of infection in the case of such diseases as malaria, bubonic, smallpox, typhoid and dysentery had not been found, there could have been no such amazing urban concentration as the world has seen during the past hundred years. That is another way of saying that there could have been no development of great industrial establishments, for the big industries are virtually all of them in or near the great cities. This, of course, is not an accident. It is something that had to be. Industrial production seeks economies by enlarging its scale. Its influence on population becomes centripetal because the thousands of workers in giant industries must live within a reasonable radius of their work. The automobile has helped to widen this radius, but even so the worker dislikes to live more than a half-hour from his labor. It becomes essential to the progress of industry, therefore, that great centers of population shall be reasonably safe against those inroads on health which would ordinarily result from congestion. Medical science has made them more than reasonably safe. It has made them safer against water-borne and insect-borne diseases than are the rural areas.

The conquest of typhoid, for example, is one of the spectacular achievements of the past generation. Fifty years ago no large American city was ever free from this disease. Epidemics of it were of such common occurrence that people regarded them with the same nonchalance that they now look upon traffic fatalities. But to-day there are large cities which go through the year without a single case of typhoid. When Sir William Osler published the first edition of his "Practice of Medicine," he devoted more space to typhoid than to any other acute disease. Now it has become one of the rarer afflictions, so much so that general practitioners often do not encounter a single case of it in years.

During the Spanish War (1898) a division of about 12,000 American troops was encamped for a few months at Jacksonville, Florida. More than three thousand cases of typhoid developed at that camp. But during the World War (1917–1918) a division of troops numbering more than 25,000 men was trained for a longer time at the same place, and not a single case of typhoid occurred. That is a striking example of what medical progress was able to accomplish in twenty years. Protection of water supplies and anti-typhoid inoculation combined to eliminate what had been for many generations one of the epidemics of every military encampment.

III

Then there is the progress that has been made in the field of surgery. Industry in all civilized lands has gained enormously by the better treatment of injuries resulting from industrial accidents at the time they occur. Few people realize how much time was lost to the

worker in earlier days by reason of accidental injuries. Accidents were numerous, and their frequency was not wholly due to the lack of mechanical safeguards. Many of them were the result of defective eyesight, which went uncorrected. The science of optometry was still in its primitive stages; defects in the vision of industrial workers were badly diagnosed and even more crudely remedied.

Injuries which involved even minor amputations had a fatal outcome in a large percentage of cases. Lord Lister, although he was perhaps the most eminent of nineteenth-century English surgeons, had an operative mortality of about 45 per cent. after amputations during the earlier part of his professional career. And industrial accidents which did not involve amputations usually resulted in prolonged lay-offs because the injuries could not be induced to heal. It was not until the last quarter of the nineteenth century that the antiseptic, and later the aseptic, treatment of injuries became general. Even then the technique left much to be desired. There are those still living who can remember the time when minor cuts and abrasions led almost inevitably to suppurations which incapacitated workers for weeks at a time. To-day the amount of time lost by either agricultural or industrial workers as the result of injuries is relatively small. Their productive capacity has been proportionately increased.

The loss of workers' time because of minor illness has also been greatly reduced. To take only one example, the improvements in the preservation of food have cut down the prevalence of ptomaine poisoning, diarrhea and other intestinal upsets to a small fraction of what they used to be. Infected teeth and tonsils were prolific causes of impaired physical vigor fifty years ago but were rarely recognized as such. More often than not, moreover, the onset of a communicable disease escaped detection until after fellow workers had been directly exposed to the contagion. Men and women with tuberculosis struggled along with their work, coughing and expectorating, quite unmindful of the danger to others. It would not be an overstatement to say that the physical capacity of the average industrial worker in the United States has been at least doubled during the past half century as the result of improvements in medical and surgical science.

Progress in medical science has also had far-reaching repercussions upon the development of agriculture. The vast extent of the dairying industry is largely due to it. Most people do not realize that only during the past hundred years has milk become a prime staple of human consumption. If there had been any such general use of milk in human diet before the days of Pasteur as there is to-day the ravages of fluid-borne disease would have swept the cities everywhere, for milk is potentially the most dangerous of all the commodities which people consume. No other article of nutrition is so easily contaminated, and in the case of no other article are the results of pollution likely to be so serious. For when pathogenic bacilli get into milk, they find a culture in which, under favorable conditions of temperature, they multiply with extreme rapidity. Then they go directly into the nourishment of those who have the least individual resistance to infection, the children and invalids of the community. Nevertheless, from being potentially the most dangerous of foods, milk has now become one of the safest. This safety, which is the result of progress in bacteriological science, has built up a billion-dollar industry in the United States.

On the other hand, the wheat farmer has not fared so happily as the result of what medical authorities regard as an advance in the science of dietetics. Even

a generation ago bread was regarded as the staff of life. In every American home it came on the table three times a day. And among staples of family diet the potato ran it a close second. But with large elements of the population both these foods are now in eclipse. Both are losing ground. The per capita consumption of bread in the United States is to-day smaller than it was at the beginning of the twentieth century. It is not because bread is more expensive or less palatable now than at that time, but largely because of the conviction that eating bread disposes to overweight, and with the feminine half of the population, this alone is enough to render it taboo. The American wheat farmer is having his troubles, and they are not wholly due to the shrinkage in his foreign market. Accepted ideas concerning the relation between diet and a slim figure have had much to do with it. So serious to the baking companies has the situation become, at any rate, that they have launched a great advertising campaign to reestablish bread and allied products in the public favor.

Where cereals have lost ground, fruits and green vegetables have gained. Dietary advice from the medical profession has substantially affected the consumption of other foodstuffs and to that extent has deflected the normal course of agricultural production. But there is one field in which the American people pay little or no attention to medical advice, or, indeed, to advice from any quarter. The consumption of beer is declining while that of spirituous liquors is increasing year by year. Whether the substitution of canapés and cocktails for bread and beer will augment the physical vigor of the race is open to something more than doubt.

IV

Perhaps the greatest progress that medical science has made during the past century is in the reduction of infant mortality. The death rate among babies to-day is not a quarter of what it was a century ago. Birth rates have also been declining, it is true, but not fast enough to offset the gain. The increase in world population has been more largely due to this factor than to any other. Life expectancy, when reckoned at birth, has therefore been greatly lengthened. When reckoned at subsequent stages along the journey it has also been lengthened, although, of course, not so greatly. The result has been to draw a larger percentage of the population into the upper decades of age distribution. Or, to put it more baldly, the progress of medical science has had a good deal to do with the growing seriousness of our old-age pension problem. It has enabled a steadily greater proportion of the people to prolong their lives beyond the age of sixty or thereabouts, that is, beyond the point where they can compete in productive capacity with younger workers.

This large and steadily increasing group, finding itself crowded out of gainful employment by the competition of younger men and women, now insists that it shall be supported by the contributions of those who have done the crowding out. It is not an unreasonable demand by any means, although one may venture to add that the problem of devising a practicable way of meeting it will not be solved by adopting any of the crackpot schemes which are now being promoted without regard to their general economic implications.

This problem remains one of the most urgent and perplexing dilemmas of our time. Plagues, infections, famines, wars and ignorance of bodily hygiene took care of it in days gone by. Wars are still with us, but despite the infinitely greater destructive power of military weapons it is a fact that warfare is not relatively so destructive of human life as it was in

earlier years. This is because the losses from disease and from the fatal termination of wounds have been enormously reduced. Famines no longer take such toll among the aged as they used to do. For in civilized countries they do not occur on any large scale, and when they do happen there are relief organizations to take care of them. Ireland could have been fed during the potato famine of 1848 as easily as Belgium was succored by America before we entered the war. The difference prefigures one of the humanitarian advances which civilization was able to make during the intervening seventy years.

There is no reason to suppose that medical progress has reached its limit. On the contrary, there is every reason to expect that it will keep on devising means whereby more and more people will find themselves projected into the sixty-to-eighty age group. If we adopt the principle that all these must be supported from the earnings of workers who are in their junior decades, we should give some heed to the size of the burden which this will ultimately involve. Calculations based upon the age distribution of to-day are almost certain to prove wide of the mark. Any sound plan for old-age pensions must envisage a steady increase in the number of those eligible to receive its benefits. Hence, if the load is not to become unbearable there must be a corresponding increase in the productive capacity of those who have to carry it. So the crux of the whole problem is not who should receive pensions, or when, or how much. It is this: How can we increase the national income to a point where this large and steadily mounting cost can be borne without lowering the standard of living among those who have to pay it? In current discussion that phase of the problem has been getting far less attention than it deserves.

YOUTH, AGE AND CITIZENSHIP

NOBODY wants to set youth against old age. But the old people who have organized for their own economic interests are so much more skilful and experienced in political organization that they have a great advantage over young people. There are thirteen million people over the age of sixty in this country. They have the vote, they have plenty of time for political activity, and they know how to make political activity count. Furthermore, they can look for aid to another thirteen million people between the ages of fifty and sixty, who are already facing old age. It is not easy for these folk who have passed the peak of life to realize that twenty-four million young people between the ages of fifteen and twenty-four are climbing the hill on the other side against obstacles more baffling than anything which the older generation went through.

. . . One feels that much of current educational change is merely tinkering with machinery that has grown obsolete. One looks in vain for the radical changes that would seem to be called for when secondary education takes on new functions to serve new types of students.

Too many people seem to be victims of an unjustified faith that if boys and girls are kept during their 'teens in the red brick isolation of a school building, they will emerge on graduation day as full-fledged men and women ready for adult life in a complex and changing society. One suspects that young people must spend less rather than more time in school buildings, that schooling and useful work must go together, that young people must live more and work more with their elders in their community, if the goals of modern secondary education are to be reached.

Will the educational profession provide the imagination and leadership necessary to meet the situation? Will the lay public accept this leadership and support the radical educational changes that may be proposed?—*Robert J. Havighurst, in the Report on the Program in General Education of the General Education Board.*

BOOKS ON SCIENCE FOR LAYMEN

THE COSTS OF MEDICAL CARE[1]

HUGH CABOT has written a first-class book, but it might well be titled "The Doctor's Dilemma" instead of "The Patient's Dilemma," for fundamentally it has to do with the relationship of the physician to the problem of providing adequate medical care to all elements of the population of the United States. The book brings out the difficulties that have been encountered by the medical profession in facing certain social trends and certain inevitable changes that have come about with the advancing social patterns of American life.

While the doctor has been confused as to just how he should play his part, the intelligent citizen has been trying to find out just what should be done in order to see that he and his family receive modern medical care at a cost that could be brought within the family budget. When it is so difficult to bring about change in a wise and satisfactory manner it is natural enough for opposition to arise among those who must change with change.

Dr. Cabot shows that while great gains have been made in modern medicine the costs of medical care have steadily increased. There is no good way to provide a cheap form of medicine for one person with appendicitis and a costly form for another. Scientific knowledge has brought such basic changes in the standards of medical education and medical care that good medical care for any one or every one is requiring expanding expenditures.

In his early chapters Dr. Cabot makes the point over and over again that the findings of science are responsible for these fundamental changes and for the new methods required in medical practice. The analysis which follows of the various experiments that have been undertaken in spreading costs among large groups of individuals or even giving national spread to them is informative and is necessary for an understanding of practical suggestions for an American program of medical care.

As a physician the author of this book understands the predicament in which physicians, nurses, hospitals and others find themselves in relation to the problems of costs, and is aware of the various obstacles that have been set up by physicians, as organized in state and national societies, largely through fear of change and a consciousness of the vital importance to satisfactory medical care of a personal relationship between the doctor and patient.

There has been an impression among certain sections of the public that if the government stepped into the picture and provided funds the problems of medical care would rapidly disappear. Dr. Cabot is wise enough to realize that the mere provision of funds will not solve the problems of good medical care and may even intensify them. There are, though, certain factors involved and these include the resources of the government as well as all other forms of social organization in which medicine is involved.

The author explains that new patterns and new techniques are needed to meet this country's problem of extending the application of the benefits of the health sciences; that effective action depends upon some combination of resources from *Government*—federal, state and local, from the *Public*—as patients, and from the *Medical Profession*—as the technicians; that leadership can but come from the profession, aided by experts in economics and government; that promo-

[1] *The Patient's Dilemma.* By Hugh Cabot, x+284 pp. $2.50. Reynal and Hitchcock, Inc.

tion of scientific study, high standards of education, opportunities for efficient work will have to be safeguarded, as schemes are designed for equitable financing and sound administration.

Dr. Cabot does not under-estimate the difficulties; he does not over-estimate immediate results nor forecast Utopia; he does believe that, with the spread of knowledge of the benefits to be gained from medical science, public demand for these benefits rightfully increases; he does believe that efforts to anticipate and meet this demand are important to our democracy; and he does believe this accomplishment is possible through democratic processes.

When he says: "I am giving voice to 'the faith that is in me,'" Dr. Cabot expresses reliance upon a philosophy of action in dealing with public matters which is rooted in idealism similar to that which guides most physicians in matters of service to the sick. It is the sort of thinking that can find the way over, around and through the obstacles which stand in the way of spreading the benefits of medicine and which will help the profession and patients to go at common problems together.

The spirit of Dr. Cabot's book can best be understood by his last paragraph on "Long Distance Planning in Democracy":

> . . . we have an immense body of opinion, part of which is in this country, a handsome part of it elsewhere, which continues in spite of discouragements, to believe that there is in all human beings an inherent and irresistible desire for certain freedoms which can be obtained only under democracy. Such a view seems to me based upon irrefutable evidence going back to the beginnings of the world. Its validity I can not doubt. Once we admit this premise, once we admit that we believe that there are in democracy certain inherent benefits essential to progressive civilization, then we are driven to the conclusion that though long distance planning under democracy is beset with many vicissitudes, nevertheless such plans must be made and, by dint of good temper and the laws of the cosmos, they may come to fruition.

RAY LYMAN WILBUR, M.D.

PRESERVATION OF MENTAL HEALTH[1]

THERE exists in this country a large body of intelligent and thinking citizens who desire authoritative information on matters pertaining to health and its preservation. The wide interest in mental health is due in part to the fact that more beds are provided in mental hospitals than in all the other hospitals of the country put together, but in greater part to the close tangency of psychiatry to many fields of human activity, and to the fact that especially in times like those in which we now live nearly every one is aware of the need of a certain amount of effort in his attempts to preserve mental equilibrium.

As a means of "fulfilling its sole purpose, that of advancing the interests of science and society," the American Association for the Advancement of Science in December, 1938, presented a symposium on Mental Health, the 49 papers and 41 discussions of which form the present volume. Dr. Walter L. Treadway, then assistant surgeon general of the U. S. Public Health Service, drew up a systematic plan and secured the services of prominent authorities in the fields of psychiatry and such related topics as social work, statistics, anthropology, occupational therapy and psychology.

For obvious reasons, the substance of this volume can not be abstracted within the limits of a review; indeed, each article is compressed within such limits that it can be summarized only with difficulty. An idea of the scope may be conveyed by enumerating some of the subjects discussed: Orientation and

[1] *Mental Health.* Edited by Forest R. Moulton and Paul O. Komora. 470 pp. $3.50. 1939. The Science Press.

Methods in Psychiatric Research, including, for example, Research Problems in the Field of Clinical Psychiatry, Abnormal Behavior in Childhood, and The Function of Biometric Methodology; Sources of Mental Disease: Their Amelioration and Prevention (Genetics and Heredity, Alcoholism and Mental Disease, The Vitamins, Immigration and the Mental Health of Communities); Economic Aspects of Mental Health (Magnitude of the Problem, Economic Loss Due to Mental Disease, Family Care of the Mentally Ill, Social Security Measures as Factors in Mental Health Programs, Influence of Economic Factors); Physical and Cultural Environment in Relation to the Conservation of Mental Health (Community Differences and Mental Health, Selective Internal Migration, Segregated Communities and Mental Health, Political Psychiatry); Mental Health Administration (Purposes of a Centralized State Administrative Organization, A State Program for the Supervision and Training of the Feebleminded, Admission to Hospitals for Mental Disease, Psychiatric Expert Testimony, Psychiatry in the Community, Statistics in Relation to Mental Hospital Administration, Mental Health Administration as a Function of Government); Professional and Technical Education in Relation to Mental Health (Criteria of Specialists, Clinical Training of Psychologists, Status of Psychiatric Nursing, Training of Psychiatric Social Workers, Relation of Psychiatry to Internal Medicine). The volume concludes with a chapter by way of summary and prospects, entitled "Human Needs and Social Resources," by Dr. C. Macfie Campbell, of Boston.

The book is comprehensive, thorough and authoritative, and should be read by all who have a serious interest in social problems and in the preservation of mental health, with all which that implies for the welfare of the individual and the group.

WINIFRED OVERHOLSER, M.D.

A LONG PERSPECTIVE[1]

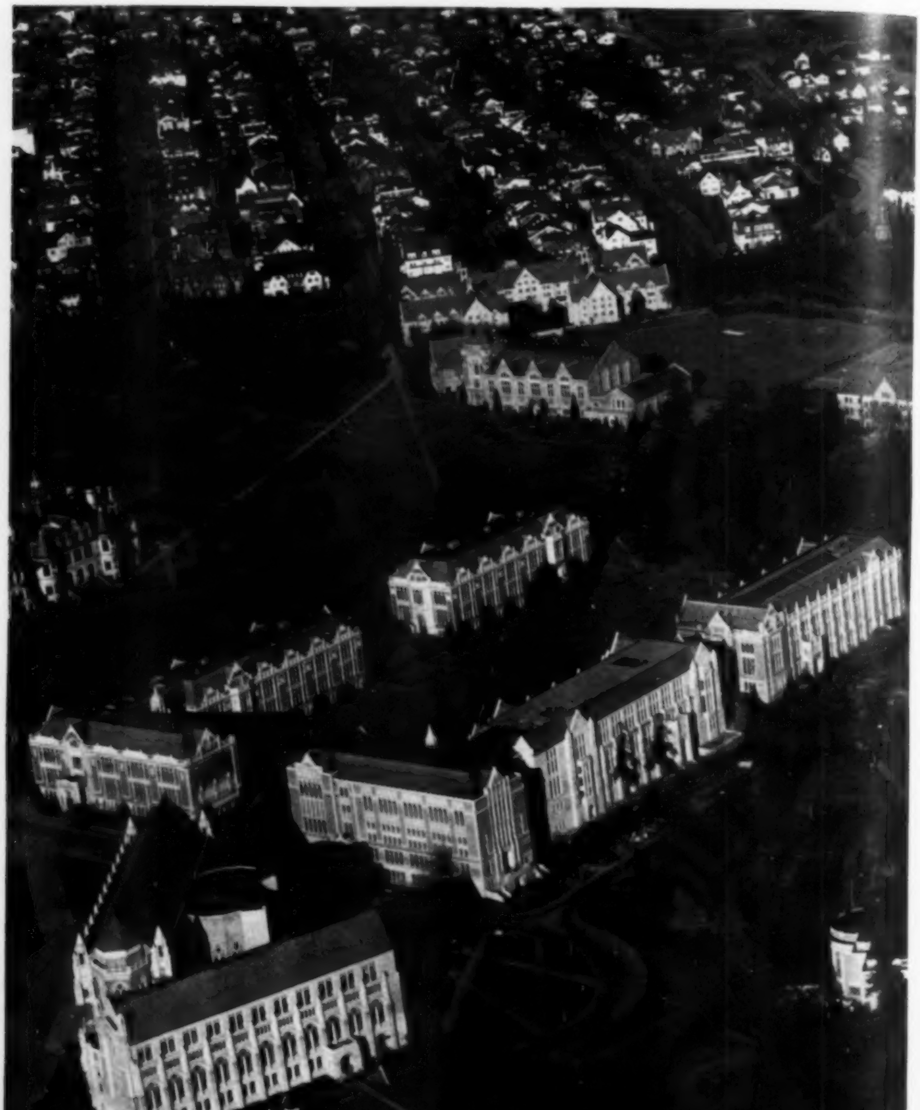
THIS new book by Childe, the author of many books and articles on archeology and the early history of man, is not simply a fascinating account of the rise of civilization. It describes with admirable clarity the accomplishments, the primitive scientific discoveries, that have marked the beginning of new epochs in human progress. For example, the author presents a very fine discussion of the importance of human speech both as a means of making available the experiences of one person for the information of others and also as an indispensable aid to generalizations and what is often termed "abstract thinking."

In a chapter on "Time Scales" the author gives a succinct and vivid outline of what is known of man down to the historic period. He warns his readers of the considerable uncertainties of the dates assigned to various prehistoric remains and of the dangers of assuming that primitive peoples of to-day are similar to prehistoric men.

In a final chapter following discussions of various "revolutions" in the culture of ancient civilizations in Asia, Egypt and Europe, Childe considers the question of the acceleration and retardation of progress. This chapter is a penetrating discussion of the deep-seated causes of the advances and the declines of civilization, a discussion doubtless stimulated in part by present world conditions and especially interesting because of them. The book is admirably adapted for the non-specialist in the history of the rise of ancient civilizations.

F. R. M.

[1] *Man Makes Himself.* By V. GORDON CHILDE. xii + 275 pp. $2.50. 1939. Oxford University Press.



AN AERIAL VIEW OF THE UNIVERSITY OF WASHINGTON CAMPUS

SHOWING THE LIBERAL ARTS QUADRANGLE IN CENTER, THE HENRY A. SUZZALLO LIBRARY IN LEFT CENTER AND PHYSICS HALL, HOME OF THE PHYSICS DEPARTMENT, IN CENTER FRONT.

THE PROGRESS OF SCIENCE

SCIENTISTS PONDER AT SEATTLE

About 1,100 scientists assembled in Seattle, Washington, from June 17 to June 22, to attend a joint meeting of the American Association for the Advancement of Science and its Pacific Division. During the five days of the meeting 644 addresses and papers were delivered or read. The subjects discussed ranged all the way from exterior galaxies of billions of stars to subatomic units of matter; from flights in the substratosphere to plumbing the depths of the ocean; from the restless mind of man to the half-live viruses. While one group was looking back down the long vistas of the geological ages another was considering phenomena lasting only a millionth of a second; while one was absorbed in the abstractions of mathematical analysis another was engaged in the immediately practical problem of growing food.

There was variety in the scientists as well as in their specialties. They came from 31 states, though largely from the Pacific Coast, and from Canada and the Philippines and Hawaii and England and France. There were American-born and European-born; there were veterans in science, and there were those who were just entering on its adventures.

It would be easy to write of interesting aspects of science that were discussed at the meeting of the association in Seattle, of the importance of the papers presented, of the enthusiasm of the participants, of the bright hopes for the future progress of science. However, all these things are characteristic of every meeting of the association, and at Seattle something entirely new was happening. World-shaking events were taking place in Europe. Those were the days in which the Allied armies were crumbling before the German attacks and when several million homeless refugees were pitiably struggling in misery to escape destruction. Every paper and radio report brought accounts of new horrors—death from the land, the sea, the air, to armies and civilians alike; the French pleading for an armistice; a government, if not a civilization, dying.

Naturally the minds of every one turned continually to these swift and tragic developments; the reactions to them were various, for scientists first of all are human beings. Though they condemned the German, the British and the French leaders, sometimes in strong terms, there was nevertheless a rare restraint in judgment, an exceptional degree of tolerance for those whom they censured. For example, there was no hysterical raving against Hitler or wishing that he might be assassinated or die a horrible death. The scientists showed that they are emotionally more mature than average men and women.

A much more interesting fact is that their training, their habit of looking for causes and taking the long view, led many of them to ponder the meaning of the present conditions. As scientists, they had gloried in the achievements of science—the superstitions and fears it has banished, the deep satisfactions in understanding the universe it has given, the food and comforts and improvements in health it has provided. How often they had boasted of these things and claimed that science promises the millennium! But wait! The engines of destruction laying waste Europe are also the inventions of science. The underlying causes of the current wars are due to the applications of science; the almost instantaneous dissemination of news of it is by means of the instruments of science. It is said, but with small comfort, that the ills the world now suffers are due to perversions of science—the same could be said of religion and even of the good-

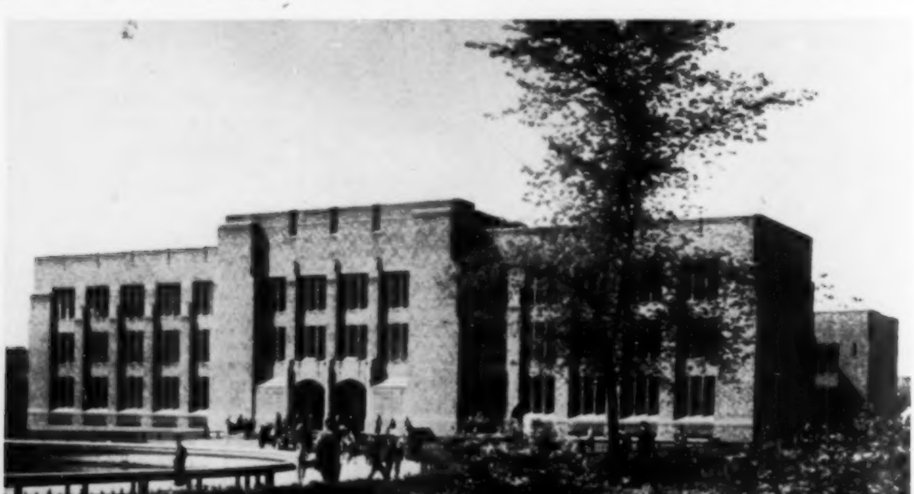
ness that keeps whispering in our own hearts.

Many scientists were pondering deeply on the causes of the grave problems civilization must immediately face. Within their own memories—within 40 years—there have been more advancements in science than in all the previous history of the world! And education has been extended everywhere by leaps and bounds! In this period high-school graduates in our country have increased tenfold; college graduates, fivefold; the doctor's degree, eightfold; library facilities, sevenfold; university endowments, twelvefold. And what is the result?

As facilities for production have been improved by applications of science, increasing numbers of people have suffered want—"one third of our people are ill fed, ill housed, and ill clothed." Ten millions are out of work and billions of dollars are being spent for relief. In spite of all the means science has provided for creating wealth, our per capita public debt has increased twenty-fold in a generation. On every hand there are pressure groups for larger gratuities and special favors, ranging from the Youth Congress to tottering Townsendites; from farmers to factory workers. As education has increased, dissatisfaction, disillusionment and cynicism have also increased. One is inclined to sing "Lead, kindly light, amid the encircling gloom."

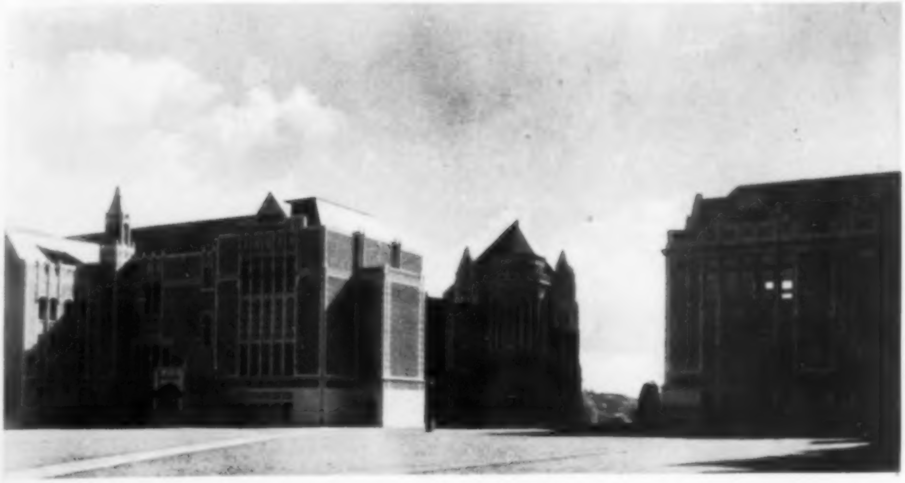
Such are natural thoughts in times of extreme stress, but they are morbid thoughts, unbalanced, incorrect. For every unfavorable new condition there are two of the opposite character. Even the losses of life in war are many times overbalanced by the saving of life through sanitation and medicine. Armies strike down, but thousands of organizations raise up—churches, schools, clubs, Boy Scouts, 4-H clubs, hospitals, social centers, the Red Cross, etc.

Although scientists realize the seriousness of present world conditions, they have no fear that the human race will become biologically exhausted; it is increasing in numbers with great rapidity and probably on the whole in physical vigor. They do not fear that civilization will be destroyed or pass into a long eclipse; it has much too great vitality. But they do realize that science has suddenly placed mankind in a new and much



SUMMER MEETING HEADQUARTERS OF THE ASSOCIATION

DANIEL BAGLEY HALL, HOME OF THE DEPARTMENT OF CHEMISTRY AND THE COLLEGE OF PHARMACY.



GROUP OF BUILDINGS OF THE UNIVERSITY OF WASHINGTON
Left to right: CONDON HALL, HENRY A. SUZZALLO LIBRARY AND PHILOSOPHY HALL.

more complex environment than the old, requiring many readjustments and re-orientations that may be long in the making.

For these reasons scientists no longer assume that their scientific work simply adds to a world that otherwise remains the same, but normally all their science will be joined in their thoughts with its effects on civilization. More frequently in the future programs of the association will be essentially, if not formally, on Science and Society.

F. R. Moulton

LEO H. BAEKELAND AND ARTHUR H. COMPTON, FRANKLIN MEDALISTS

Distinguished contributions in the fields of applied science and of pure science received equal recognition recently when the Franklin Institute bestowed its highest award, the Franklin Medal, upon Leo Hendrik Baekeland, inventor of the synthetic resinous substance, bakelite, and upon Arthur Holly Compton, whose work on the properties of x-rays has won him renown throughout the scientific world.

Though Dr. Baekeland is best known for his invention of bakelite, he has made significant contributions in other fields. A native of Belgium, Dr. Baekeland came to the United States in 1889. After a short period during which he was employed as chemist by A. and H. T. Anthony and Company, then the largest photographic supply house in the United States, Dr. Baekeland and Mr. Leonard Jacobi founded the Nepera Chemical Company, located in Yonkers, New York, for the manufacture of photographic papers and chemicals. One of the products of this company was "Velox" paper, which constituted a distinct step forward in the art of photographic printing. In 1899 the company sold out to the Eastman Kodak Company and Dr. Baekeland turned his attention to chemical research. One of his achievements during the period of consultation work which followed was the development to the commercial stage of C. P. Townsend's invention of an electrolytic process for producing caustic soda and chlorine from a solution of common salt.

Dr. Baekeland's most important work has been in connection with the chemical

Photograph by Gladys Müller

AFTER THE PRESENTATION OF THE FRANKLIN MEDAL

DR. LEO H. BAEKELAND EXAMINES THE MEDAL WHICH HAS JUST BEEN PRESENTED TO HIM BY MR. PHILIP C. STAPLES, PRESIDENT OF THE FRANKLIN INSTITUTE, WHILE DR. KARL T. COMPTON LOOKS ON. DR. COMPTON ATTENDED THE CEREMONIES TO RECEIVE THE FRANKLIN MEDAL AWARDED HIS BROTHER, DR. ARTHUR HOLLY COMPTON, OF THE UNIVERSITY OF CHICAGO.

reaction between carbolic acid and formaldehyde. By heating the product of this reaction under pressure, he turned the viscous mass into an insoluble solid with an appearance like amber or ivory, which could not be melted again, was easy to mold, was resistant to moisture and to chemical reagents and which did not conduct electricity. This invention was the beginning of the modern plastics industry, the products of which are so widely used to-day.

Dr. Baekeland has received many honors and awards. He has been the recipient of the Nichols Medal, the Willard Gibbs Medal, the Chandler Medal, the Perkin Medal, the John Scott Medal and the Messel Medal.

Photograph by Gladys Müller

THE FRANKLIN MEDAL AWARDED TO DR. A. H. COMPTON

THE GOLD MEDAL, DESIGNED BY THE LATE R. TAIT McKENZIE, IS TWO AND ONE HALF INCHES IN DIAMETER.

The award to Dr. Compton was in recognition of his brilliant experiments on various properties of x-rays, some of which involved new methods of attack, and, in particular, for his discovery and theoretical treatment of the Compton Effect.

Dr. Arthur H. Compton graduated from the College of Wooster in 1913. Ten years later he was professor of physics at the University of Chicago, occupying one of the most important professorships of physics in the country, which position he still holds. During the interim he had obtained his degree of doctor of philosophy from Princeton University, held the position of instructor in physics at the University of Minnesota for a year, spent two years as research physicist with the Westinghouse Lamp Company, one year at the Cavendish Laboratory in Cambridge as a National Research Fellow, and three as professor of physics at Washington University. Dr. Compton has been the recipient of many honors and awards, including the Nobel Prize in physics in 1927.

Dr. Compton's early work on the total reflection of x-rays incident upon a metallic surface at a very small angle led to a new method of measuring the wave-length of x-rays, namely, the ruled grating method, the results of which are now regarded as more exact than those obtained by the earlier crystal method of Bragg—results from which have been calculated more reliable values of fundamental physical constants.

In 1923 Dr. Compton investigated the nature of x-rays which had been scattered by matter. For such scattered rays the

Photograph by Gladys Müller

A GROUP OF THE MEDALISTS

Seated, left to right: LAURENS HAMMOND, MAXWELL M. UPSON, PHILIP C. STAPLES, PRESIDENT OF THE FRANKLIN INSTITUTE, RICHARD L. TEMPLIN AND EDWARD E. KLEINSCHMIDT. *Standing, left to right:* GAMES SLAYTER, FREDERICK M. BECKET, ROBERT R. WILLIAMS, JOHN F. FLAGG, WILLIAM E. WOODARD, DR. HENRY B. ALLEN, SECRETARY OF THE FRANKLIN INSTITUTE, LEOPOLD D. MANNES, LEOPOLD GODOWSKY, JR., CHARLES ROSENBLUM AND HOWARD L. KRUM.

old electromagnetic theory predicted no change of wave-length, whereas the new quantum theory predicted a modification in wave-length. Dr. Compton's photograph showed the existence of both types of ray. He explained the modified wave-length as due to a collision of an x-ray photon with a free electron, the photon bouncing off in one direction with a changed wave-length and the electron recoiling in an opposite direction. Application of the quantum theory led to equations which checked with experiment. Thus Dr. Compton not only discovered a new phenomenon, which now bears his name, but also gave its correct theoretical interpretation—a dual feat of great brilliance.

In recent years Dr. Compton's chief work has been in the field of cosmic rays. From his world-wide survey in the early 1930's, he concluded that these rays are largely composed of enormously energetic electrified particles. Other cosmic ray problems are being attacked systematically by Compton with the assistance of other observers in various parts of the world.

These awards of the Franklin Medal were presented at the exercises on the Franklin Institute's Medal Day, at which time Cresson Medals were awarded to Frederick M. Becket, of the Union Carbide and Carbon Corporation, for his development of low carbon ferro-alloys and his contributions to electrometallurgy, and to Robert R. Williams, chemical director of the Bell Telephone Laboratories, New York, for his researches upon Vitamin B_1, including its isolation in the pure state in quantity sufficient for further chemical study, the identification of its segments and its synthesis in quantity. On the same occasion Wetherill Medals were awarded to Laurens Hammond for his electric organ,

and Edward E. Kleinschmidt and Howard L. Krum for their work in the development of the teletypewriter. Longstreth Medals were awarded to Leopold Godowsky, Jr., and Leopold D. Mannes, the inventors of Kodachrome film; Games Slayter, of the Owens-Corning Fiberglas Corporation, for his improved methods and apparatus for producing glass filaments; Richard L. Templin, of the Aluminum Company of America, for his deformation recorder; and Maxwell M. Upson, of the Raymond Concrete Pile Company, for his contributions to the scientific development of foundation engineering and construction.

The Henderson Medal, presented for distinguished contributions in the field of railway engineering, was awarded to William E. Woodard, of the Lima Locomotive Works, in consideration of his accomplishments in locomotive engineering and his important contributions in the field of steam locomotive design. The Levy Medal, awarded for a paper of especial merit published in the *Journal of the Franklin Institute*, was presented to Charles Rosenblum, of Princeton University, and John F. Flagg, of the University of Rochester, for their paper entitled "Artificial Radioactive Indicators."

JOHN FRAZER

AN EXPEDITION TO STUDY BIG-GAME FISH

ONE of the most extensive undertakings ever attempted in the study of big-game fishes has been under way for several years by the Michael Lerner-American Museum of Natural History Expeditions. The large, pugnacious game-fishes, such as broadbill swordfish and the various species of marlin, have

MEMBERS OF THE BIG GAME FISH EXPEDITION AT TALARA, PERU

Front row, left to right: VIBO VALENZIO, IRVING HARTLEY, DAVID DUNCAN. *Back row, left to right:* CAPTAIN DOUGLAS OSBORNE, HELEN LERNER, MICHAEL LERNER, FRANCESCA LAMONTE, CAPTAIN BILL HATCH.

continued to be baffling mysteries as to their breeding habits and migrations. A new expedition under the same sponsorship has now extended its field research to the Humboldt Current waters off the coasts of Peru and Chile. These expeditions have journeyed to the far corners of the world each summer since 1936, and although satisfactory advances have been made in the knowledge that has been attained, there are still many missing links in the chain of evidence.

The Peru-Chile expedition is the fifth one conducted by Michael Lerner for the American Museum of Natural History in association with members of the museum's scientific staff. From 1936 to 1938 Lerner expeditions studied the Atlantic coast swordfish off Louisburg, Cape Breton, and the marlins in the waters off Bimini. Last year runs of the Pacific species of these fish were investigated off New Zealand and Australia. The object of the 1940 expedition in going to Peru and Chile is to determine if the swordfish and marlin there are the same as those found in western Pacific waters.

Research of this type has to be done in the field because of the difficulty in transporting huge fish to museum laboratories. To insure a continuous supply of fresh specimens for scientific study, swordfish and marlins are collected on rod and reel by Mr. and Mrs. Lerner, both experienced big-game anglers of world-wide renown. Miss Francesca LaMonte, associate curator of the Department of Ichthyology, is the scientific leader of the expedition. She conducts studies in the field, for stomach contents, sex and parasites, all of which provide clues for the solution of the mysteries regarding the homes and habits of these fish.

One of the most remarkable facts about broadbill swordfish is that they seem to be the same all over the world in appearance and anatomical structure. This, however, does not apply to the marlins, which run in the same waters. It is important to find out how to tell one kind of marlin from the other. There are blue, black, white and striped marlins, and until they can make a thorough examination of large numbers of all these varieties they can not tell whether there are seven or eight kinds of marlins or whether there are only two or three despite differences in coloring and markings. Previous studies of marlins made by the Lerner expeditions in the Gulf Stream and in Australia and New Zealand have recorded the differences in color patterns, body forms and fins. In the present expedition field laboratories will be established at Talara, Peru, and Tocopilla, Chile, for the further study of the same problem.

On the return trip a stop will be made at Cuba to investigate recent theories that the waters off that island may be breeding grounds for the Atlantic run of both swordfish and marlin.

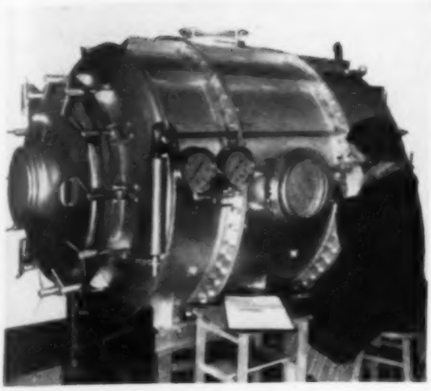
In addition to Mr. and Mrs. Lerner and Miss LaMonte, members of the expedition include the following: photographers, Irving Hartley, of New York City, and Vibo Valenzio, of Ozone Park, L. I.; fishing guide captains, William Hatch and Douglas Osborne, of Miami, Fla.

WILLIAM K. GREGORY

OXYGEN REQUIREMENTS AT HIGH ALTITUDES

COLONEL LINDBERGH, in a report to Congress, emphasized the necessity of increasing the facilities in this country for research in the various fields connected with aviation. Of these fields none has been more neglected than that of aero-medical research.

While the effects of anoxemia (insufficient oxygen) at high altitudes have been long recognized, it is only within the last two or three years that any material advance has been made in perfecting apparatus for the administration of oxygen to pilots, crew and passengers of



PRESSURE CHAMBER
WITH TECHNICIAN AT CONTROLS OBSERVING AND TALKING BY TELEPHONE TO SUBJECTS INSIDE.

airplanes. The studies of Boothby, Lovelace and Bulbulian, which led to the development of a comfortable type of apparatus that required only one quarter to one fifth as much oxygen per minute per individual as had been previously required, have led to substantial progress on one of the many practical problems that need immediate attention.

Another important problem that must be clarified as soon as possible is that concerned with rapidity of ascent. Airplanes are being constructed which are reported to be able to ascend at the rate of about a mile per minute. How fast can the human body be decompressed from full nitrogen saturation at sea level? Can the tables of decompression first worked out by Haldane and recently modified by Lt. Commander C. B. Momsen, Lt. A. R. Behnke and their associates in the Laboratory of the Experimental Diving Unit, Navy Yard, Washington, D. C., be extrapolated to pressures of less than one atmosphere?

ANALYZING ALVEOLAR AIR
METHOD OF OBTAINING AND COLLECTING SAMPLES TO CHECK AMOUNT OF OXYGEN REQUIRED PER MINUTE WHEN USING THE B. L. B. INHALATION APPARATUS IN ORDER TO MAINTAIN A NORMAL PARTIAL PRESSURE OF OXYGEN IN THE LUNGS AT ALL ELEVATIONS.

INSIDE THE CHAMBER
OBSERVATIONS BEING MADE BY THE TECHNICIAN ON A SUBJECT LYING DOWN IN THE CHAMBER; BOTH ARE OBTAINING OXYGEN BY USE OF THE INHALATION APPARATUS.

Is it possible that the timetable of decompression can be safely shortened in aviation by preliminary decompression with oxygen? Even at full saturation at one atmosphere, the mass of nitrogen in the tissues will be only a fourth that at four atmospheres, as in diving operations; therefore, when bubbles form, the amount of such bubbles will be smaller and possibly less likely to cause serious injury. Even if bubbles in the blood stream do cause trouble, will immediate recompression by descent remove the ill-effects with sufficient rapidity to prevent a crash?

These and many other problems need immediate investigation, and for these

purposes the Mayo Foundation has installed a pressure chamber in the Laboratory of Metabolic Investigation in which both low and high pressures can be developed with sufficient rapidity to obtain data upon these points. Other phases of aero-medical research will be studied, especially from the point of view of prevention, not only in the normal and adaptable individual but also in aged and sick persons. The precautions and facilities necessary to transport patients safely by air must also be investigated.

J. R. M.

THE BRINE-SHRIMP ARTEMIA AND ITS ENVIRONMENT

A NUMBER of small organisms inhabit salt lakes in the desert and brine pools which occur along the ocean shore in regions of low rainfall where salt is concentrated by solar evaporation. One of the most conspicuous of these is the brine-shrimp *Artemia*, which is found in water more saline than the sea in many parts of the world. Under protected conditions in the laboratory it thrives and completes its life cycle in sea water, but it is defenseless against marine predators which prize it highly as food. In nature *Artemia* capitalizes on its unusual ability to withstand extreme conditions and develops in great numbers in water so saline or alkaline that enemies can not follow. *Artemia* are abundant in the Great Salt Lake, which contains a salt mixture much like that of the sea except that it is more than seven times as concentrated. They are also very abundant in Mono Lake, which is highly alkaline.

In "Roughing It," Mark Twain (with a very considerable degree of exaggeration) describes the effects of Mono Lake water on a dog with sores which made a mistake in judgment and jumped in. There was soon no bark left, inside or out, but the dog reached shore and struck out over the mountains. Mark Twain wrote that nine years later it was still going. He also describes the *Artemia* and notes their great abundance. Without exaggeration, it can be stated that *Artemia* may swim about for ten or fifteen minutes in undiluted Bouin's fluid (picric and acetic acids and formaldehyde). Oddly enough, *Artemia* is relatively intolerant of potassium, and its distribution in the American desert is affected by this factor. It has been reported that it will hatch throughout the pH range 2 to 13.

Artemia is a primitive arthropod of the class Crustacea. The adult body is divided into a large number of segments, and there are many appendages adapted for swimming. The size and morphology of *Artemia* varies greatly with the salinity of the habitat, but the adult is commonly about half an inch long.

Small salt lakes and brine pools often dry up completely, and this is fatal to the adults and active young. Deserts are also subject to extremes in temperature. The *Artemia* are prolific, and the species of the western United States reproduce in two ways. Actively growing larvae are released from the uterus of the mother as nauplii, but at other times embryos are encased in a heavy chitinous shell which is secreted by the oviduct of the mother. These heavily encased embryos, which are often called cysts, are inactive and may be dried without harm. In fact, it is beneficial if not essential for them to be dried before they will hatch out as nauplii and resume development in a suitable liquid medium. The cysts, which are about one fifth of a millimeter in diameter, may hatch after a number of years in the dry state, and they maintain the *Artemia* in temporary salt lakes and ponds. The cysts also adhere to the feathers of water birds and serve as a very effective means of dispersal. Whenever a new salt pond is established, *Artemia* are apt to appear even if the nearest known source of *Artemia* is far away. So commonly are they associated with brine pools that some salt-makers are said to believe that

salt can not be made from sea water without them.

In some localities adult *Artemia* are collected in large quantities and fed to tropical and other aquarium fishes. The cysts are also collected and distributed commercially to fish fanciers who can hatch them conveniently at any time to provide a highly prized living food.

Protoplasm which is relatively dehydrated is generally resistant to extreme temperature and, since this condition is associated with an inactive state, to lack of oxygen as well. The dry *Artemia* cysts are no exception. It has recently been shown that they may be submerged in liquid air, at $-190°$ C., for 24 hours without affecting the rate of subsequent hatching, or the percentage which hatch. Cysts have also been maintained in high vacuum (10^{-6} mm Hg), so far for six months, with the same result. Since the high vacuum deprives the cysts of moisture as well as oxygen, it appears that no degree of desiccation is too great for them. The fact that they can survive without oxygen for at least six months indicates that their resting metabolism may be reduced to an extremely low level.

DOUGLAS WHITAKER

STRANGER THAN FICTION

AT a conference of astronomers held in Paris a year ago, Dr. G. P. Kuiper, of the Yerkes Observatory staff, announced the discovery of a star, known as Wolf 457, whose average density is about 500,000,000 the density of water. This is the densest matter known. A cubic inch of it at the surface of the earth would weigh about 9,000 tons!

The mass of the sun is about 330,000 times that of the earth. The mass of the dense star is about 20,000,000 times that of the earth, or 60 times that of our sun. Yet it is smaller than the moon, its diameter being only 3,000 miles. An object on its surface would weigh 55,000,000 times as much as it would on the surface of the earth. A cubic inch at the average density of the star at its surface would weigh 55 million times 9,000 tons or 495 billion tons.

The star is so small that it would be quite invisible even through large telescopes if its surface were not extremely luminous, as it is because its surface temperature is about 30,000 degrees Centigrade, or about five times the surface temperature of the sun. Since the rate of radiation of a luminous body varies as the fourth power of its temperature, the surface brightness of this remarkable star is about 600 times that of the sun.

Ordinarily the nature of a substance is determined from examinations of various of its properties, as its color, hardness, specific gravity, chemical reactions, melting point, etc. But all that is known about this dense star is inferred from the faint light that is received from it, for at a distance of many light years it is quite beyond the reach of all senses except that of sight. Yet the light of a star generally carries more information than many a bulky tome filled with the crude characters that are used in attempting to express what is in some muddled mind. With almost unerring precision it reveals the temperature of the radiating source, the chemical constitution of it and its state.

By its state I mean in part the extent to which its atoms are stripped of its outer electrons. In this remark is the principal key to the explanation of the very dense stars. For some reason not yet known the atoms of these stars have lost their far-wandering electrons that ordinarily give them bulk, and they consist only of their exceedingly dense central parts. Therefore they lie close to one another somewhat like shot in a pile.

Is this only a dream? It is hardly more questionable than nearly everything that we accept as certain. In comparison with it general philosophical principles and theological doctrines are extravagant extrapolations from experience. But our minds have become accustomed to them,

whereas matter millions of times as dense as water is a stranger to us and therefore to be rejected.

Not long ago the possibility that the earth has existed for many millions of years seemed equally fantastic and only 25 years ago even astronomers recoiled from the suggestion that our galaxy is composed of billions of stars and that there are exterior galaxies so far away that light from them is on its way millions of years before it reached us. How sure we are of the familiar and how fearful of the unknown.

F. R. M.

EFFECTS OF SULFANILAMIDE ON TOBACCO PLANTS

SULFANILAMIDE is undoubtedly one of the most important artificial chemical compounds that has ever been placed at the disposal of medicine. During the past three years it and its related compounds have been found to produce beneficial, and in some cases remarkable, effects in a wide variety of bacterial diseases. In recognition of the importance of these new chemicals, the discoverer of some of the therapeutic properties of sulfanilamide, Dr. Gerhard Domagk, of Germany, has recently been awarded a Nobel prize in physiology and medicine.[1]

It is, of course, very gratifying to medical men that the sulfanilamide group of compounds has remarkable curative properties for animals infected with quite different kinds of bacteria. But this fact proves that the action is not *specific*, in the sense that various kinds of bacteria are stained only by different kinds of dyes, doubtless as a consequence of definite chemical interactions between the dyes and certain of the many chemical constituents of the organisms. Nor is the action *general* in the sense that it has destructive effects upon all organic tissues, as strong acids and alkalis have, for if it were general these compounds would be destructive to the host as well as to the infecting organisms. As a matter of fact, it is not yet known just why the sulfanilamide compounds cure any disease. When the mode of their action is finally understood, wide new doors of progress may be opened to medicine.

Since bacteria are low forms of plants, it might be suspected that the sulfanilamide compounds would have marked effects upon higher plants. This would be at the most only a suspicion, however, because these chemicals have much less marked effects upon bacteria in the test-tube than in the animal host. It is generally believed that the action upon the organisms is not direct but that in some way the infected animal participates in it.

In order to throw light upon these questions, Dr. Ernest L. Spencer, of the Rockefeller Institute for Medical Research, has been investigating the effects of sulfanilamide on seedlings of Turkish tobacco plants. He finds several interesting results. The first is that sulfanilamide is a very effective growth-promoting substance, stimulating root proliferation on cuttings of the plants, but not on uncut seedlings. The second effect is that tobacco seedlings are extremely sensitive to the toxic effects of these chemicals. Strangely, concentrations of sulfanilamide which stimulated root formation in cut plants were strongly toxic to plants with normal root systems. The third notable effect is the nature of the toxic effects, which closely resemble the physiological disease "frenching," which has been known for 250 years.

At the moment the experiments and observations of Dr. Spencer appear to add to the confusion of many unexplained facts. They are, however, additional pieces in the jigsaw puzzle whose eventual assembly will almost certainly result in a new and beautiful pattern, as interesting from the scientific point of view as it will be important from the practical point of view.

F. R. M.

[1] See the January issue of this journal.